ENGINEERING

THE UNIVERSITY
OF MICHIGAN
AUG 11 1961
ENGINEERING
LIBRARY

roduct Profile:
ociété Genevoise
g Borer

esearch:
lans for a Large
lectron Microscope
ponsored Production
esearch Pays Off

Design:
arge Output
ydraulic Power Vibrator

pecial Articles :
rmy Fire Power :
ank and Anti-Tank Guns

Construction:
educing Seepage
ast Earth Fill Dams

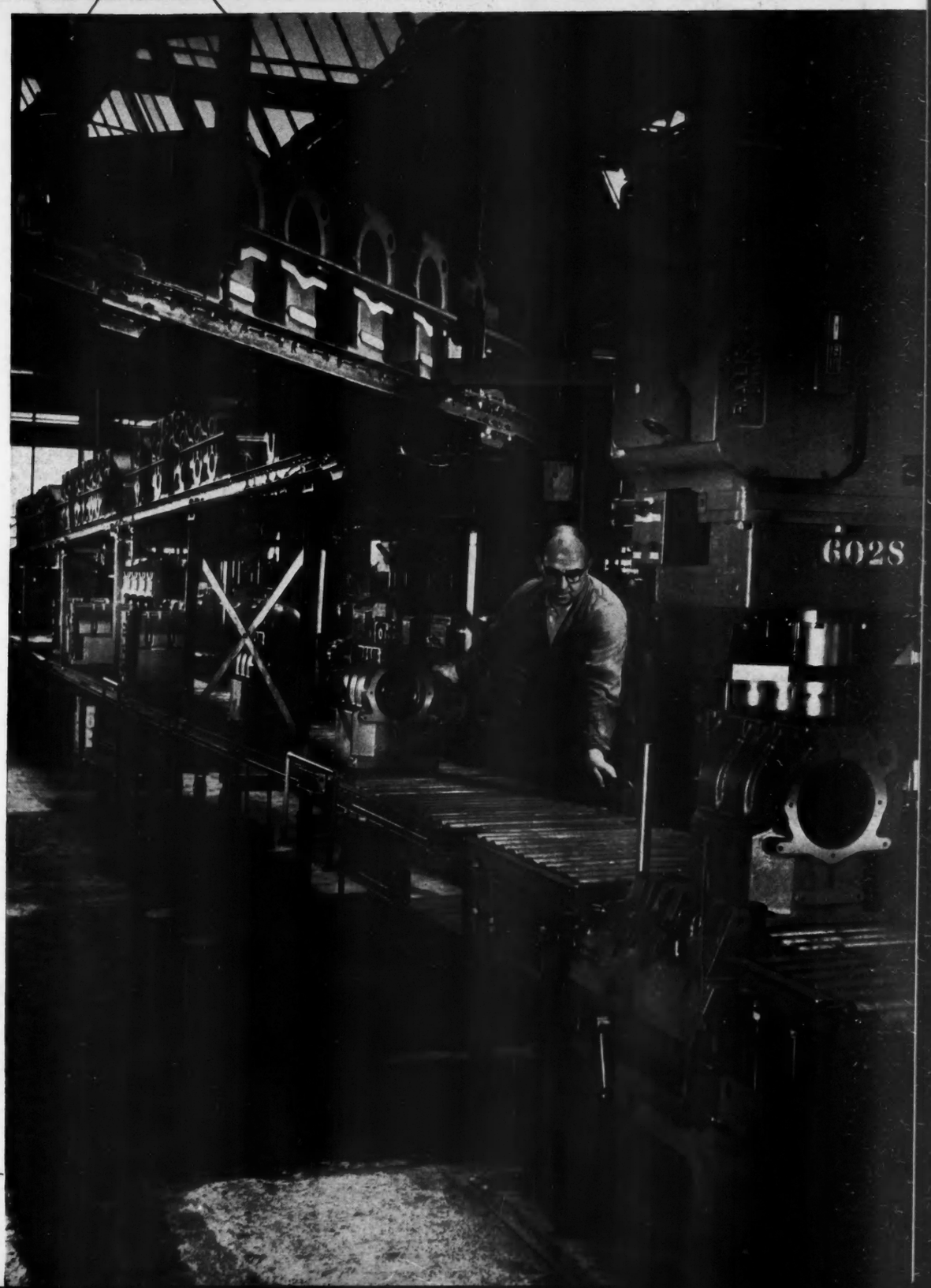
Production:
erformance of
achine Tool Slideways

Metals and Materials:
oating Two High Pressure
ater Tunnels

Automobile Review:
errari GP Successes
ue to Foresight

RICE
2/-

oring Crankcases



HADURA FORGED STEEL ROLLS

Hadfields forged steel rolls are universally employed for the cold reduction of ferrous and non-ferrous sheet and strip, and conform to the highest standards required in application and service.

Rolls for unusual or complicated applications are a speciality. Service and technical advice are readily available.

HADFIELDS SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

21 July 1961

Vol. 192 No. 4970

Founded in 1866

ENGINEERING

PUBLISHED EVERY FRIDAY

36 Bedford Street London WC2 England Telephone : Temple Bar 3663

Contents

66 Design

Large Output Hydraulic Power Vibrators

Long and Short Range Anti-Tank Missile

Solid Fuel Packaged Boiler, Ballast Machine Cleans 300 tons per Hour, Vertical Car Park

76 New Plant and Equipment

Multi-Tool and Copying Lathe, Side Entering Mixers, Compact Valves, Shearer Pick, Time-Division Multiplex System, Pre-heat Indicator

Mobile Cleaning Equipment, General Duty Drills, Insulation Tester, Electric Jig Grinder, Lighting Controller, Wire Strippers

74 Construction

Reducing Seepage Past Earth Fill Dams

Corrosion Protection of a Service Main, Railway Electrification of India's Industrial Belt

82 Metals and Materials

Coating Two High-Pressure Water Tunnels

Pvc Coated Terylene Duct for Aircraft, Asbestos Brake Lining for Cable Layer, Glass Reinforced Plastic for Destination Box, Stainless Steel Casting Agreement, Ptfe Monofilament Made in UK, Strippable Coating for Paint Spray Booth

84 Production

Slideway Wear Factors in Machine Tools
By R. C. Brewer

94 Research

Research Report:

Plans for a Large Electron Microscope
By A. Franks and J. S. Halliday

Sponsored Production Research Pays Off

65 Impact

73 Human Element

81 Companies

89 Marketing

72 Automobile Review

Ferrari GP Successes Due to Foresight
By Brian Lister

Special Articles

70 Bonus to Britain of a Satellite Scheme

78 Army Fire Power: Tank and Anti-Tank Guns
By R. M. Ogorkiewicz

80 Atomic Review

Flux Distribution

90 Product Profile

Société Genevoise Jig Boring and Milling Machine

96 At Home

Gutters and Pipes—Non-Metallic

69 Plain Words

By Capricorn

69 Letters to the Editor

Cornish Engineers and the Steam Engine
John D. Troup

69 Events in Advance

86 Publications

On the Shelf
By Frank H. Smith

Books Reviewed:

Elektrothermie
The Complete Scientist
Directory of Opportunities for School Leavers, 1961
Theory of Thermal Stresses
Understanding Organizational Behaviour

Trade Publications and New Books

Cover Picture

The bores of a three-cylinder crankcase being machined simultaneously on a three spindle vertical boring machine fitted with an air-operated fixture. An overhead roller track brings the crankcases to a point above the borer and they are lowered automatically on to the lower track ready for machining. (*Nurnberg photograph for* ENGINEERING)

Advertisers in 'Engineering' this week

	PAGE
AEI-Birlec Ltd.	27
Abbot Eng'g Co., Ltd.	16
Acheson Colloids, Ltd.	52
Appleby - Frodingham Steel Co.	24
Armstrong Stevens & Son, Ltd.	59
Associated Electrical Industries, Ltd. Motor & Control Gear Division	40
Atlas Copco AB. (Sweden)	25
Babcock & Wilcox, Ltd.	17
Balfour, Arthur, & Co., Ltd.	38
Barimar, Ltd.	11
Barry, Henry & Cook, Ltd.	44
Bellis & Morcom, Ltd.	54
Belmos Co., Ltd. *Wrapper*	VII
Booth, Joseph, & Bros.	51
British Paints, Ltd.	65
British Steam Specialties, Ltd.	59
Broom & Wade, Ltd.	22 & 23
Brown, David, Corpn. (Sales) Ltd.	39
Brown, N. C., Ltd.	16
Clark, Geo., & Sons (Hull) Ltd.	49
Clayton-Wright, Howard, Ltd.	16
Clyde Crane & Booth, Ltd.	51
Clyde Crane & Engineering Co.	51
Cohen, George, Sons & Co., Ltd. *Wrapper*	VIII
College of Aeronautics	7
Cox & Danks, Ltd.	8
Crane, Ltd.	52
Crompton Parkinson, Ltd.	14
Dallow Lambert, Ltd.	50
Davy-Ashmore, Ltd. *Wrapper*	III
Douglas, Lawson & Co., Ltd.	44
Dyson, R. A., & Co., Ltd.	54
Eagle Pencil Co.	49
Elliston, Evans & Jackson, Ltd.	12
English Electric Co., Ltd.	30
Epsylon Industries, Ltd.	2
Ferodo, Ltd.	58
Ferranti, Ltd. *Wrapper*	VI
Fielding & Platt, Ltd.	9
Firth Brown Tools, Ltd.	18
Fleming & Ferguson, Ltd.	15
Flight Refuelling, Ltd.	10
General Electric Co., Ltd. of England	64
Govan Shafting & Engineering Co.	8
Graphite Products, Ltd.	26
Green, R., Ltd.	45
Greenwood & Batley, Ltd.	67
Greenwood's Standard Gear Cutting Co., Ltd.	59
Hadfields, Ltd. *Wrapper*	II
Harland Eng'g. Co., Ltd.	43
Harland & Wolff, Ltd.	44
Harvey, G. A., & Co. (London) Ltd.	47
Hayward Tyler & Co., Ltd.	2
Holland, B. A., Eng'g. Co., Ltd.	11
Holroyd, J., & Co., Ltd.	55
Howden, J., & Co., Ltd.	37
Hunt, R., & Co., Ltd.	26
Intermit, Ltd.	5
International Nickel Co. (Mond) Ltd.	33, 34, 35 & 36
Joy-Sullivan, Ltd.	28
Lafarge Aluminous Cement Co., Ltd.	57
Lambhill Engineering Ltd.	6
Lanarkshire Bolt, Ltd.	60
Ledward & Beckett, Ltd.	4
Leeds Eng'g. & Hydraulic Co., Ltd.	65
Lincoln Electric Co., Ltd. *Wrapper*	IV
London Shafting & Pulley Co., Ltd.	60
McGraw-Hill Publishing Co., Ltd.	4
Mastermodels, Ltd.	21
Menrow Pumps, Ltd.	63
Mercer, T., Ltd.	8
Michell Bearings, Ltd.	54
Midland Silicones, Ltd.	29
Mono Pumps Ltd.	63
Osborn, S., & Co., Ltd. *Wrapper*	V
Pegler & Louden, Ltd.	12
Phosphor Bronze Co., Ltd.	12
Pinder W., & Son, Ltd.	27
Pitman, Sir Isaac, & Sons, Ltd.	4
Polypenco, Ltd.	8
Pool, J. & F., Ltd.	15
Pulsometer Pumps, Ltd.	60
Reavell & Co., Ltd.	13
Reyrolle, A., & Co., Ltd.	20
Richards, C., & Sons, Ltd.	63
Rocol Ltd.	61
Rose, Downs & Thompson, Ltd.	56
Rubert & Co., Ltd.	8
Scott, Hugh. J., & Co. (Belfast) Ltd.	43
Seagers, Ltd	44
Service Electric Co., Ltd.	11
Simplifix Couplings, Ltd.	7
Smith & McLean, Ltd.	7
Sound Control, Ltd.	66
Spiro-Gills, Ltd.	68
Steele & Cowlishaw, Ltd.	45
Super Oil Seals & Gaskets, Ltd.	15
Suteliffe, R., Ltd.	48
Taylor Bros. & Co., Ltd.	53
Thomas, R., & Baldwins, Ltd.	19
Tinsley, H., & Co., Ltd.	26
Tufnol, Ltd.	31
Turner Bros. Asbestos Co., Ltd.	54
United Steel Companies Ltd.	24
Visco Engineering Co. Ltd.	41
Vokes, Ltd.	46
Wailes Dove Bitumastic, Ltd.	62
Ward, Thos. W., Ltd.	42
Wigglesworth, Frank, & Co., Ltd.	59
Wiggin, H., & Co., Ltd.	32

'Engineering' Appointments Section inside Editorial Section

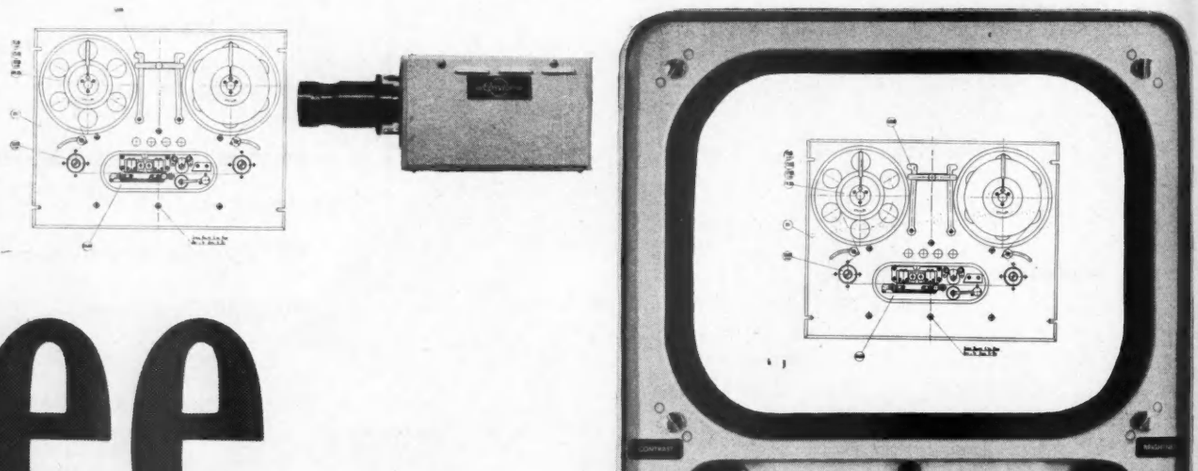
	PAGE
British Titan Products Co., Ltd.	4
Caltex Services, Ltd.	3
Central Electricity Generating Board	5
Laing, John, & Son, Ltd.	4
Lever Brothers (Nigeria) Ltd.	2
Management Selection, Ltd.	3
National Coal Board	4
Qatar, Arabian Gulf Shiekhdom of	1
United Kingdom Atomic Energy Authority	4
Yorkshire Imperial Metals Co., Ltd.	1

Classified: Trade & Technical

	PAGE
Allmodels Studios	3
Bell, H., (Machine Tools) Ltd.	3
Braintree & Bocking U.D.C.	3
Cambridge Consultants Ltd.	3
Cohen, Geo., Sons & Co., Ltd.	3
Edwards, F. J., Ltd.	3 & 4
Government Surplus Stores	3
India Store Department	3
New South Wales, Govt. of	3
Norris Bros., Ltd.	3
Research Engineers, Ltd.	3
Simm, G. E. (Machinery) Ltd.	4
Ward, Thos. W., Ltd.	4
West Norfolk Fertilisers	4

For Engineering' Appointments Section, turn to the centre of Editorial Section

HAYWARD TYLER & COMPANY LIMITED P.O. BOX 2 LUTON ENGLAND TEL: LUTON 6820-30 LONDON OFFICE SCHOMBERG HOUSE 82 PALL MALL LONDON S.W.1 TEL: TRAFALGAR 2284-7



See with Epsylon TV

Why waste time when time means money? Bring the facts to your desk as you need them with the flick of a switch. Epsylon TV gives you a powerful range of easy-to-use facilities; the highest standards of definition; the most reliable, economical and versatile system of television for industry and research. Keep yourself in the picture about Epsylon TV.

Epsylon

KEEPS YOU IN THE PICTURE

EPSYLON INDUSTRIES LTD
Faggs Road, Feltham, Middlesex, England.
Tel: Feltham 5091-4

A MEMBER OF THE STONE-PLATT GROUP

ENGINEERING Impact

of United Europe and British Industry

THE statement from the Federation of British Industries on the issues involved in British relations with the European Economic Community is timely in bringing out the major points when prolonged and impassioned debate has raised temperatures rather more than the level of information.

The FBI sets out the three basic questions at the heart of the argument. They are: whether the existing Common Market members will be ready to negotiate conditions that may be essential for the United Kingdom; whether the signatories of the Treaty of Rome will agree to terms which would prevent undue damage to Commonwealth countries and to our mutual trade with them; thirdly, whether the Six would be prepared to negotiate the special conditions needed by Britain's partners in the European Free Trade Association.

No open answer appears to have been made from the Common Market to the indication by the British Government that they would be ready to think in terms of a common or harmonized tariff on industrial raw materials, semi-manufactured and finished goods, subject to satisfactory arrangements for the Commonwealth and EFTA.

The FBI statement suggests that to the EEC countries two other factors are of over-riding importance.

Damage to Commonwealth

The first of these is acceptance by the United Kingdom of the proposed common agricultural policy (on which there is more than one opinion in the Community) whose effects are likely to be restrictive and of great potential harm to Commonwealth producers. This policy particularly affects temperate food products and there are also a number of substantial difficulties among tropical products. The second point to which great significance is attached by the ECM members is the United Kingdom's acceptance of the full range of institutions, with their political implications, set up by the Community. It is on the far reaching, supranational effect of such industry controlling bodies that much political and trade union feeling is being aroused in Britain.

Declaring its own position before commenting on these complex issues, the FBI says plainly: "We would not support any solution which in effect meant that the Commonwealth was to pay a substantial part of the price for British association with the Common Market."

The FBI also points out that it is imperative that Britain's contractual and moral obligations to the European Free Trade Area nations must be honoured in full.

Commenting on the issues that directly affect industry, the FBI is not opposed in principle to the Government's suggested common or harmonized tariff. The Federation would not oppose in practice a common or harmonized tariff on industrial products at the level of the EEC common tariff expected to obtain at the time of a British entry.

The abiding interest of the UK in Commonwealth development makes it important that any association should lead to expanding markets for Commonwealth producers, especially those in developing countries. In the field of raw material imports the FBI (surely with the unanimous support of its members) would certainly deplore changes which would on balance substantially increase industrial costs.

In connection with imports of manufactured goods the FBI raises the question of low-cost Asian manufactures. British industry, already carrying a disproportionate share of low-cost imports, recognizes that economic expansion in Asia and elsewhere is to its ultimate benefit, but a spreading of this burden is overdue.

Ending Preference?

A point whose full significance is not perhaps as readily appreciated as some others is that the British Government has stated that it will not oppose other Commonwealth members should they choose to bargain away preferences they now give to British exports in return for more liberal treatment from the European Community. This price, which British industry might have with reluctance to pay, would be much higher for some industries than others, though the preferences are of some importance to most concerns.

Among other problems of greater or less importance, the FBI wants "adequate provision for strong, quick action against dumped and subsidized imports as an integral part of any settlement." On restrictive practices, the vague provisions of the Rome Treaty and the varying interpretations being made are thought likely to create great uncertainty and endless legal difficulties.

In conclusion the FBI recalls that it has always desired a Europe-wide multilateral trading system as, it believes, has the great majority of European industry. While being ready to welcome an early end to the present division of Europe the majority opinion within the FBI is against being committed to formal negotiations with the Six until existing differences over the problems considered have been narrowed to the point where the prospect of a satisfactory outcome has appeared.

And, of course, preoccupation with EFTA-Commonwealth-EEC problems must not be allowed to obscure the pressing need to expand British exports in every possible market, not least that of the Rome Treaty countries.

Hovercraft Abounding

DEVELOPERS of the hovercraft in this country will doubtless be enthusiastic about the application, by the Liverpool airline, Starways, for permission to operate a network of hovercraft services in and around Britain.

Their application, now before the Air Transport Licensing Board, includes ferry services across the Thames, the Mersey, the Severn Estuary, between Liverpool and the Isle of Man, Belfast, Dublin, Glasgow, Holyhead and Stranraer. The list further includes services between Portsmouth, Southampton, Bournemouth, and the Isle of Wight. Other services are envisaged to France, Belgium and Holland. The shorter services, such as those across the Thames and the Mersey would be for vehicles as well.

It is anticipated that the initial development programme for the hovercraft will be quite close to Starway's base at Liverpool Airport. This has a frontage on the River Mersey at Speke, where a river crossing problem already exists due to tidal activity. The heavy volume of traffic wishing to cross the Mersey puts an increasing strain on the present tunnel and ferry facilities.

The company envisage the craft being used for the carriage of passengers, vehicles and freight and although they have not yet decided on the particular size to be used they are thinking in terms of a hovercraft in the region of 25 tons. Long term plans will be based on a craft of 50 tons load with an all-up weight of about 120 tons. The company are anxious to induce the manufacturers to produce larger models. Several factors obviously affect the venture, such as the date of issue of operational licences, availability of the hovercraft, and the training period for crews.

It is interesting to recall that, recently, William Denny and Brothers—the Scottish shipbuilders who already have a 4½ ton sidewall hovercraft—announced they are to build a craft to carry about 70 passengers which will be used as a ferry.

of Getting Ideas Over to Builders

THE need for building and contracting firms to make greater use of technical information—and new developments—is the opening shot from the Building Research Board in their annual report, *Building Research* 1960 (HM Stationery Office, 7*s*). "We believe," say the Board, "that an immediate and important step forward in the technical efficiency of most building firms would be the allocation to one senior member of their staff of the duty of keeping up with technical matters." It can be added, for the benefit of those making such an appointment, that "keeping up with technical matters" is a task that takes a lot of time.

These strictures apply more to the building firms than to civil engineering contractors. For one thing, the civil engineering contractors have on their staffs people who have a good basic education in science and engineering whereas the builders, more allied to the architects, have generally had a different type of training and are not geared to receive the results of laboratory investigations. Many of the civil contractors have their own laboratories and there are various examples of good fundamental work being done in contractors' laboratories.

So far as the builders are concerned, the Building Research Station have gone a long way with their publications to give easily assimilated help. The *Building Research Station Digests* are frequently set out in question and answer form, each question dealing with one self-contained topic. And they are cheap: it is not unusual for one digest, price fourpence, to deal with four topics—a penny for each piece of good advice.

In their report the Board go on to say it is clear that from the inquiries that reach the Station "that neither the professions nor the contractors make anything like full use of all the information at present available." It may sound like heresy to research workers, but the fact remains that fullblown papers, complete with historical background, extensive algebra and long drawn out conclusions hedged about with "scientific" provisos, are not the best way to get over new ideas.

A short pungent article, going straight to the heart of one problem, is much better.

Europe's Agricultural Engineering Industry

Two years ago the manufacturers of agricultural tractors and machinery in Western Europe set up a committee known as the European Committee of Associations of Manufacturers of Agricultural Machinery (CEMA). They have recently issued a bulletin which deals with some of the problems affecting agricultural mechanization and discusses the role and activities of CEMA.

The object of CEMA is to study technical and economic problems on an international scale in order to promote European agricultural mechanization and encourage free international trade. Representing 95 per cent of European production it plays a leading role with other international organizations and in this way contributes towards the progress of world agriculture. At the same time important contacts between the agricultural machinery industries of the principal manufacturing countries of Europe—Austria, Belgium, France, Germany, Holland, Italy, Switzerland and the United Kingdom—are maintained.

Standardization

For years farmers have been pressing for the standardization of agricultural machinery to allow them to make better use of their equipment. To this end, CEMA has put forward proposals concerning the working parts of certain machinery and combine harvesters. Tractor test proposals by CEMA have been adopted by the International Standards Organisation.

Regulations differ greatly between countries in such matters as driving on public highways and in safety precautions. They can be a hindrance to trade exchanges and cause increased prices in machines which need to be modified. CEMA is looking into traffic regulations as they affect agricultural tractors and machinery of different countries, in order to attain proposals common to all. Another task is to consider safety precautions.

European manufacturers of agricultural machinery have decided to go ahead with an exchange of statistics and their Committee is working on the definition of headings and rules to be followed for exchanging information. An international terminology for agricultural machinery is also being studied. It will take the form of a glossary which will not only be of value to manufacturers but to agricultural engineers as well.

One facet of CEMA's work which will be particularly well received is the endeavour to rationalize the increasing number of agricultural shows and fairs, the duplication of which incurs heavy costs in time and money to the manufacturers, which must eventually be reflected in the cost to the farmer.

Large Output Hydraulic Power Vibrators

The hydraulic amplification of an electrical signal is the basis of the Dowty hydraulic power vibrator. Large loads can be oscillated with two types of unit.

AN ELECTRICAL signal is amplified hydraulically by the Dowty Rotol hydraulic power vibrator, thereby marrying electric signals and hydraulic thrusts.

The heart of the vibrator is the Dowty Moog servo-valve which was described in our issue of 16 July, pages 818-9. Basically it receives an electric signal from any source and converts it into accurately controlled hydraulic output.

The hydraulic power unit takes two forms. Firstly as a vibrator table (Fig. 2) to which a specimen can be attached. The unit is about 2 ft tall, weighs 1¼ tons and is cast in steel to BS 1459. It is of very sturdy construction as its natural frequency must be higher than that of the component which it is testing.

For a given size of vibrator the number of Moog valves used determines the amplitude at which can be given at a certain frequency, i.e., the speed at which a stroke can be delivered.

The second form is as a tension type vibrator as seen in Fig. 1. A simple circuit diagram is shown in Fig. 3. It is installed in a test rig (Fig. 4) by the RAE Farnborough where it is used for fatigue testing. The power input is only 100 mW through which the vibrator controls about 40 hp. To show the capabilities of the vibrator it is worth mentioning what the acceptance tests for the RAE's unit were.

(1) A mean load of 25,000 lb cycling between 15,000 and 35,000 lb at 45 c/s. Load levels held at + 2 per cent and cycling to − 5 per cent at an amplitude of 0·030 in (peak to peak).

(2) A mean load of 25,000 lb cycling between 5,000 and 45,000 lb at 17 c/s. Load levels held at + 2 per cent and cycling to − 5 per cent at an amplitude of 0·060 in (peak to peak).

(3) A mean load of 25,000 lb cycling between 0 to 50,000 lb at 9 c/s. Load levels held at + 2 per cent and cycling to − 5 per cent at an amplitude of 0·100 in (peak to peak).

Provision is made to enable the loading applied by the hydraulic jack to be measured at any time.

The unit for RAE consists of an oscillator and a dc source which feeds into a servo-amplifier and then into two Moog valves which operate in parallel. These valves control the hydraulic jack which vibrates the specimen. The Moog valves are able to hold the vibration amplitude constant by a feed back signal from strain gauges connected to the hydraulic jack, via a servo amplifier. The preloading, or mean load, on the specimen is controlled by the dc source, the oscillator being concerned with vibration about that load.

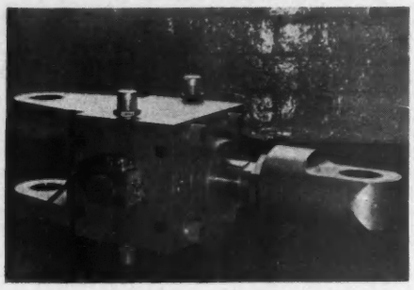


Fig. 1 (above) The tension type vibrator as installed in the A-frame in Fig. 4.

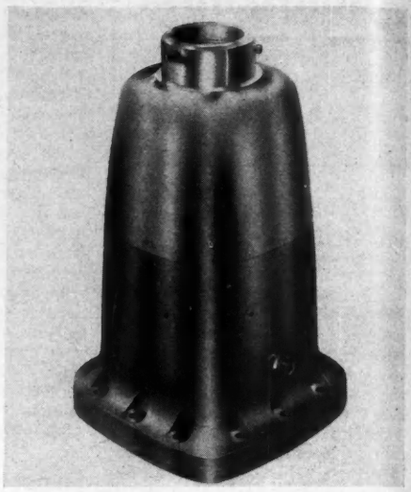


Fig. 2 (right) The table type vibrator unit which is about 2 ft tall and weighs 1·25 tons.

The work which such vibrator units can do divides itself into three parts as given below.

High Frequency Fatigue Testing

The normal range is from 0 to 100 c/s. Accelerated tensile fatigue testing of components can be achieved with this equipment. A total thrust of 50,000 lb has been obtained with pre-loads of 25,000 lb. The equipment can operate at any pre-determined fixed frequency about any mean level or it has the ability to use a random signal from a tape or other input.

Such testing could for example take the form of environmental testing of aircraft parts. Signals from a component or a structural member could be recorded on to tape. The frequencies experienced could then be hydraulically reproduced and studied at first hand in a laboratory.

Medium Frequency Vibration Testing

The normal range is from 0 to 500 c/s. The equipment for this type of work uses the table type unit and any mass requiring vibration can be attached. An industrial application of this vibrator unit would be for reproducing a vehicle suspension performance under controlled conditions.

At the Delft laboratories in Holland, resonance search tests have been conducted on a dam. The dam was excited horizontally and at other times vertically at from ½ to 3½ c/s. The amplitude of each cycle was, according to Dowty's, about an inch or two. Mounted on the bank was a hydraulic power pack, and the hydraulic pressure and flow was 3,600 lb per sq. in and 8½ gals per min respectively or equivalent to about 25 hp. Electric cables were fitted to take signals to the jack and a feedback signal fed to the Moog valve from the strain gauges.

Audible Vibration

Within a range of 0 to 1,600 c/s noise can be generated at a far greater volume than has hitherto been possible by conventional electrical means. A common example is the oscillating of a loud speaker by an electrical signal; a hydraulic vibrator could do this on a much larger scale. Fatigue damage can be brought about by noise and a component might be tested for this condition using the hydraulic speaker.

On a large ship such as one of the " Queens," probably as much as 30 hp of steam is needed to operate the siren. The equivalent noise could be reproduced with two small wires attached to a vibrator unit. At the other extreme, in medical work it would be possible to amplify the faintest pulse into a more convenient magnitude.

In the days when supersonic flying was permitted over this country the owners of glass-houses knew only too well to their cost that noise is a destructive weapon. Amplified to a large degree it could have a military potential.

Figures given by Dowty show that an electro-hydraulic vibrator is much cheaper than its electromagnetic counterpart. The RAE unit costs about £5,000 and produces 50,000 lb thrust. Electromagnetic units work out at about £17,000 for 10,000 lb thrust.

Development is continuing on this type of equipment; at the moment one unit can give from 1,000 to 50,000 lb thrust. Others may be developed to cover the 2,000 to 80,000 lb range.

Dowty Rotol Limited, Cheltenham, Gloucester.

Fig. 3 Diagram of fatigue testing vibrator.

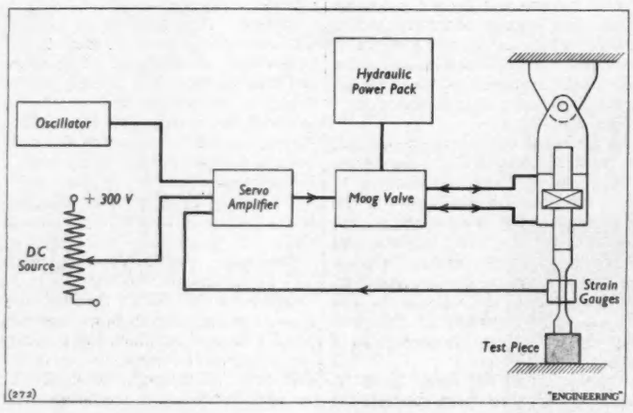
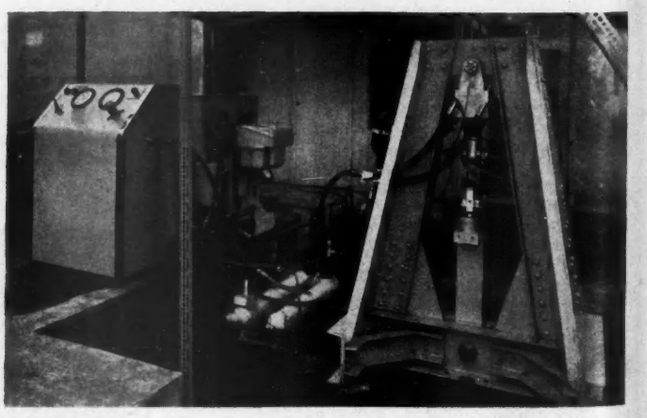


Fig. 4 The tension type vibrator installed in a test rig and used by RAE Farnborough.

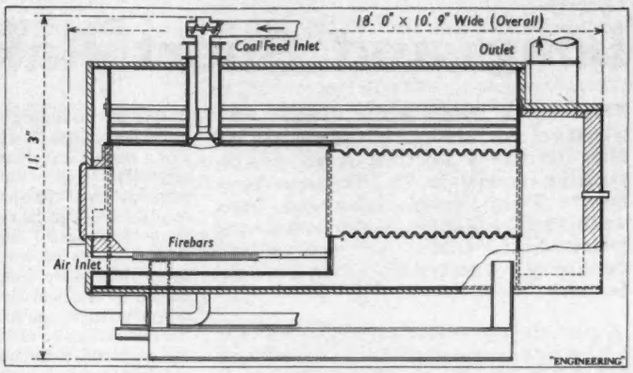


Solid Fuel Packaged Boiler

Over 1,000 oil/gas fired Powermaster boilers have now been installed by GWB Furnaces Limited. They are now marketing a new packaged boiler specifically designed for solid fuel firing which is said to give all the advantages of economical and efficient operation inherent in the Powermaster.

Known as the Vekos-Powermaster, it is delivered as a complete, compact and self-contained unit which can be easily installed and requires no special foundations. The boiler is said to give a consistent efficiency of more than 80 per cent when burning a wide range of fuels which is achieved without the use of economizers or superheaters.

All aspects of the Clean Air Act are satisfied, as are the FBI recommendations that the flue dust pollution should not exceed 0·2 grains per cu. ft. This is done by built-in multi-cell grit arresters with a unique double-firing system of collected grit. Controlled by steam pressure or water temperature, the unit is designed for operation within a firing range of 30 to 100 per cent of load. At all settings fuel and air is maintained in correct ratio and the boiler will operate at low loads with a high degree of efficiency.



Solid fuel for the Verkos-Powermaster is automatically fed from existing bunkers through the crown of the boiler to a vortex chamber supplied with air. The unit is controlled by steam pressure or water temperature.

Fuel is automatically fed to the boiler by a screw conveyor from existing storage. It is fed through the crown of the boiler to a vortex chamber supplied with air from a forced draught fan and the fuel is accordingly distributed in an even pattern on the firing bed. The air also provides over-fire secondary combustion. There are no moving parts in the furnace and the makers estimate that the grate will have a minimum life of 5 years even using low ash content fuels, and they consider this an extremely important feature from the availability and maintenance costs point of view.

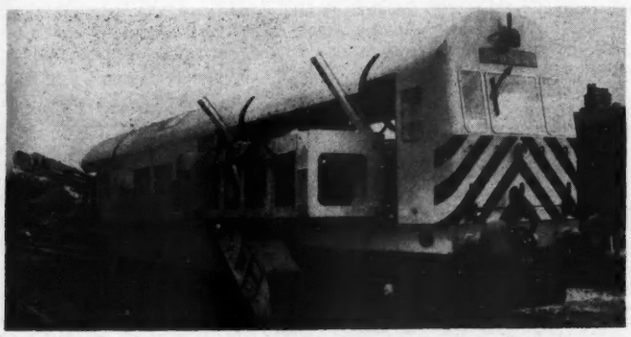
It is possible to fire the boiler by hand if necessary. The air for combustion would be induced by a natural draught and dampers are provided to bypass the multi-cell grit arresters so that boiler pressure drop would be reduced.

GWB Furnaces Limited, PO Box No. 4, Dibdale Works, Dudley, Worcestershire.

Ballast Machine Cleans 300 Tons Per Hour

Efficient drainage through the ballast with the minimum of line occupation is claimed for the ballast cleaning machine recently supplied to British Railways North Eastern Region by the Hunslet Engine Company.

When working it cleans the ballast in the shoulder and the six-foot—the area between the tracks—at operating speeds up to 600 yards per hour. In this time it can deal with 300 tons of stone ballast. If the shoulder only is being aleaned, free passage is afforded for trains on the adjacent road of a double track line. Route availability is high as the machine is designed to a 20 ton axle loading and in accordance with British Railways' L1 loading gauge.



This self-propelled ballast cleaner for British Railways can operate at up to 600 yards an hour during which time it will clean 300 tons of stone ballast.

The vehicle is self-propelled by a Rolls-Royce type C6TFL diesel engine developing 208 bhp at 1,800 rpm continuous rating. The engine drives four Deri-Sine duplex hydraulic pumps through a toothed belt and Hunslet gearbox.

A digging head is provided on each side of the machine. They are individually controlled for such things as speed of digging and depth of cut and are completely retractable by means of hydraulic rams within the body of the machine for travelling. The digging belts are each driven by an hydraulic motor and are fitted with easily removable steel picks or tines. The ballast is carried on the digging belts and deposited on conveyors which transfer it to the screens.

Double-deck vibrating screens are provided and they are divided by a centre plate to give independent screening for the left and the right hand digging heads. From the screens the cleaned ballast gravitates to chutes on either side of the vehicle and is returned to the track, the dirt being carried away by disposal conveyors.

The Hunslet Engine Company Limited, Hunslet Engine Works, Leeds 10.

Liftpark Keeps Cars Off the Ground

A vertical car park which works on the Paternoster principle of having cabins suspended from drive chains has just been introduced in this country by the Butterley Company. Price ex works is £15,000. Known as the Wulpa Liftpark it can accommodate 20 cars of 19 ft maximum length and 2 tons maximum weight.

To park his car, the motorist simply drives into the cabin at the bottom, alights, enters the kiosk and turns a key. The cabin and car then move up one side of the structure and an empty cabin takes its place ready for the next car. To retrieve his car the motorist replaces the key in the correct slot according to the number of the cabin in which his car is housed and his car is brought to ground level in an average time of 30 sec.

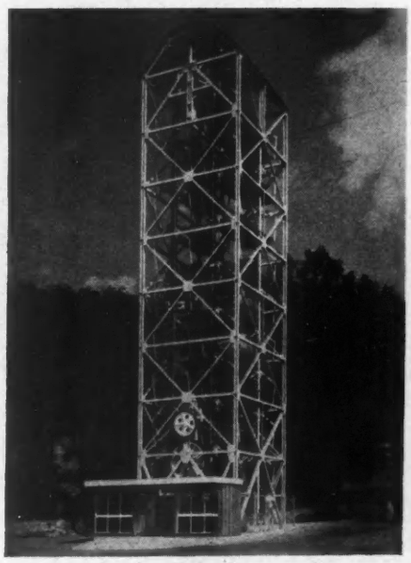
Designed to BSS 449, the Wulpa Liftpark is a bolted structure of universal columns with allowances for cladding to suit individual requirements. The structure covers a ground area of 24 by 20 ft and the height to the eaves is 75 ft.

The cabins are coupled to a pair of 16 in pitch chains each of which has an ultimate breaking strength of 135 tons. The chains run on fabricated steel chainwheels, the bottom pair of which are driven by a 45 hp electric motor through a reduction gearbox and gear train. The upper pair of chainwheels are mounted in a free-standing chassis which permits individual or simultaneous tensioning of the driving chains. A special device takes up any variation of tensioning caused by varying load.

The cabins are guided in their vertical path by nylon rollers which run in guide channels. The cabins are steadied on their path round the upper and lower chainwheels by a spider arrangement which ensures that the load is maintained through the vertical axis. Special guide rollers are incorporated in the chains which run in channel guides to ensure proper alignment.

The Wulpa Liftpark could, if required, be modified to operate vertically downwards as well as upwards, or even be considered as a horizontal unit. 60 car units are planned.

The Butterley Company Limited, Ripley, Derby.



Wulpa Liftpark can hold 20 cars.

Long and Short Range Anti-Tank Missile

The tank has long been regarded as the arch-enemy of the infantry soldier and practically immune to his counter-fire. This new weapon developed by Vickers-Armstrongs (Aircraft) Ltd., is portable, remotely controlled, and easy to use.

AFTER 4½ years intensive development as a private venture the Vickers Vigilant anti-tank missile was given its first full-scale demonstration in Britain on 7 July when the Army School of Infantry fired a total of 13 missiles on the Imber range near Warminster, Wiltshire. The targets were Centurion tanks moving at speeds of up to 18 mph at ranges varying from 400 to 1,500 yards. Hits were scored in 12 shots, the one miss being due to the breakage of the control wire which is played out behind the missile in flight. In view of the fact that this is the only failure of this kind to occur in over 100 firings, the demonstration clearly exemplified the reliability of the missile even when controlled by men of limited experience.

One of the most difficult targets to hit with a guided missile is one that only appears for a short period, thus giving no opportunity to alter the firing line and little time for the missile to reach the target. The Vigilant, with its wide deployment angle and high velocity, performs well under these conditions and it is claimed that targets have been hit during a 15 sec appearance at a range of 1,200 yards.

HIGH VELOCITY

The complete Vigilant system comprises three separate items: the carrying container, which also serves as the launcher, the missile proper, and the control unit incorporating a telescopic sight and a thumb operated trigger with which the operator is able to guide the missile into the tank. This unit is attached to the launching box by a lightweight cable 75 yards in length which enables the operator to sight the missile and then position himself to obtain the best aim. A tracking flare is provided in the rear of the missile and the operator has only to use his trigger to keep the target "covered" by this flare to score a hit. An auto-pilot compensates for course errors due to gusts of wind. For a missile travelling at a velocity of 500 ft per sec, almost twice the rate of any comparable weapon, the Vigilant is highly manoeuvrable in flight and can be deployed at an angle of 40° from the original flight path. Steering is by means of fins on the trailing edge of the four wings which are only 11 in in span and permanently attached to the body, thus obviating the erection of cumbersome appendages before the missile can be launched.

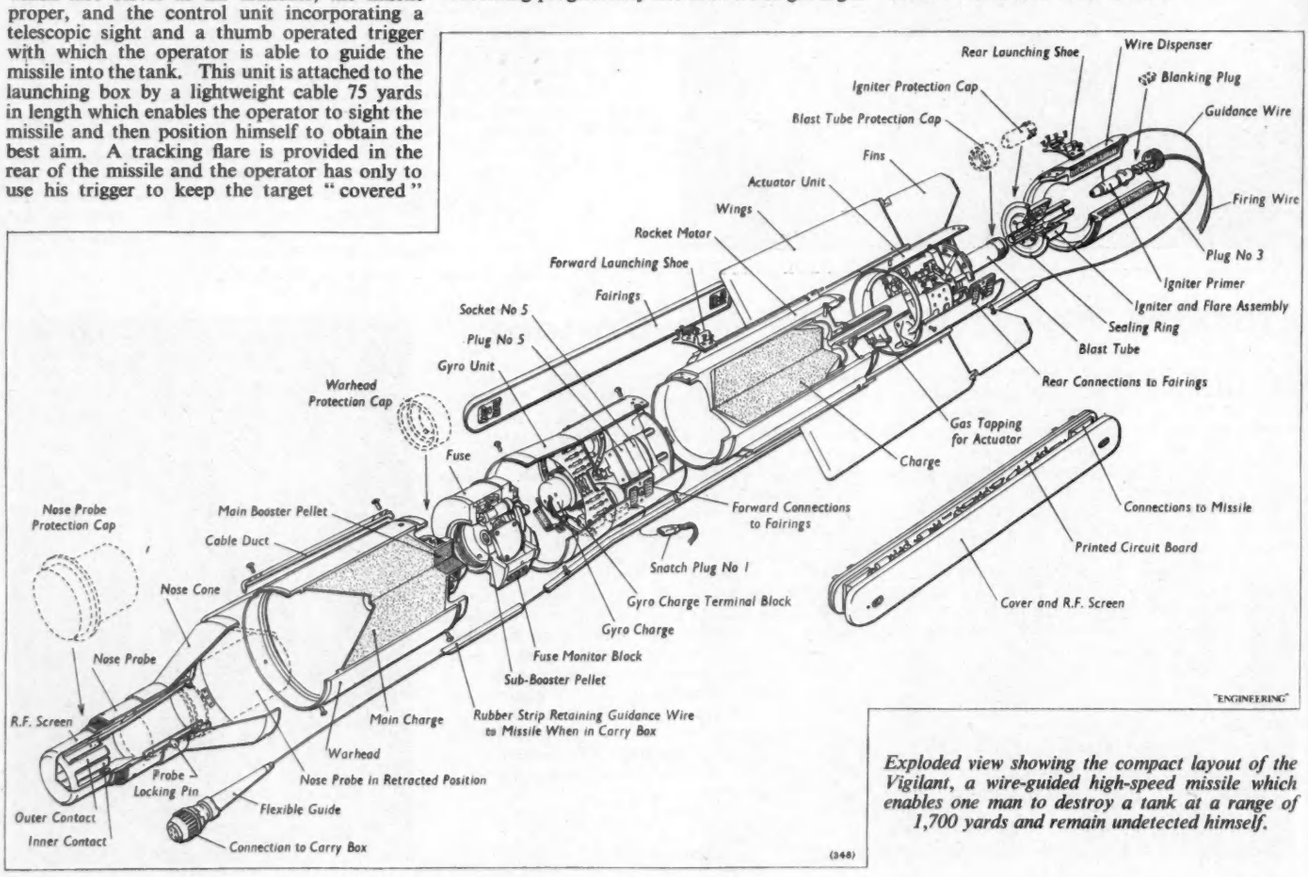
Considerable attention has been devoted to weight reduction as the original conception was to make a weapon capable of giving the individual infantryman the ascendancy against armour without causing him to be overburdened. The complete kit weighs 44 lb, of which 31 lb is the actual missile. Of this figure, no less than 36 per cent is payload and although no lethality figures have been released, it should be sufficient to pierce the most heavily armoured tank. The warhead is of the hollow type, relying on the focused blast energy of its explosive content for its effect.

Technically, little has been disclosed with regard to the construction of the missile but the accompanying sketch shows the general arrangement. On pressing the launching trigger an electrical impulse from batteries housed in the control unit passes along the firing wire to the primer of the igniter and flare assembly, which then starts the rocket motor. The first few inches of movement are controlled by the guide rails in the roof of the launching box but past this point the firing plug pulls out and the missile becomes controlled solely by the guide wire being played out from the reel housed at the rear. The first stage of the flight appears to be somewhat irregular with the meanderings becoming progressively less until a straight flight path is attained. Obviously short range accuracy is a function of the distance the missile moves in an erratic path and the design incorporates features to reduce this to the minimum. Vickers claim that hits at the astonishingly short range of 180 yards have been scored, though nothing as short as this was attempted during the demonstration. The reason for the good short range performance lies in the adoption of a velocity control system in place of the more conventional acceleration method.

Situated just behind the rocket motor is the actuator unit which picks up impulses relayed from the operator as he moves the trigger on the control unit. This alters the position of the fins to give the correct flight path in accordance with his directions. The actuator works in conjunction with the gyro unit sandwiched between the warhead and the fuel charge and automatically takes over control once the flight path has been set by lining up the tracking flare, as seen through the sight, with the target. If the gyro is unbalanced by physical conditions which may cause deviations in the flight path, an impulse passes to the actuator which, in turn, deflects the fins to a degree sufficient to bring the missile back on to its original course.

The makers claim that the advantages of this system easily justify its rather high initial cost, not only in terms of accuracy, but the ease of operation permits the use of fewer missiles required for training purposes both initially and at the refresher stage.

The rocket fuel is one which leaves practically no flame or smoke and, apart from the tracking flare which is only visible from behind, the missile is virtually imperceptible in flight. This must obviate almost completely the possibility of counter-attack as the tank would be destroyed without giving the enemy the opportunity to observe the source of the missile.



Exploded view showing the compact layout of the Vigilant, a wire-guided high-speed missile which enables one man to destroy a tank at a range of 1,700 yards and remain undetected himself.

Plain Words

By Capricorn

IN THE recent debate on science in the House of Commons, the Minister of Education, Sir David Eccles, made a special plea to industrial leaders. "I would ask them to reward," he said, "by early promotion the able scientists and technologists whom they seem increasingly anxious to recruit. I do not think industry will ever recruit really efficient manpower in adequate numbers unless the leaders in established positions give early responsibility and promotion to younger men, often with qualifications which they themselves had neither the need nor the opportunity to acquire."

Few would disagree with this advice, but there is plenty of scope for disagreement on the best way to put it into effect. The trouble is that those who are in most need of it are probably the most likely to ignore it.

Some great men are poor at delegating. Because they are great leaders they like to keep a finger in every pie, to maintain their own positions as sources of energy and drive, and to deprive those under them of the opportunity to exercise their initiative and drive.

A great man who is also good at delegating is doubly beneficial. Because he is in the habit of delegating, he freely expounds his philosophy and policy. He invites his staff to join him on his own intellectual plane, and he stretches their powers to the limit. In short, he inspires them.

The chances of working under a man of this stature are very small, particularly for engineers. If you are studying for the bar you can go to hear great advocates in action. As a student surgeon you are present in the operating theatre when a great man operates. As a young actor you can watch the great actors. As a young cricketer you can go to Lords or the Oval, or even watch the television screen.

As a young engineer you have little chance of sitting at the feet of a master. The greatness of a great engineer is not to be observed at one performance, within a couple of hours. It is spread over years. It may go unrecognized until, in retrospect, we all say "He was a great engineer." In the engineering profession, some are born to greatness, and some achieve greatness, but few have it thrust upon them.

I have no idea how it could be done, but I do feel strongly that engineers in the early days of their careers could do with much more opportunity to work close to men of exceptional powers. It is all very fine to work alongside fitters and turners and welders—and a very valuable experience, too—but it is at least as important to sharpen your intellect on the minds of men you hope to emulate. To be close to greatness is to aspire to greatness yourself. It gives you a chance to acquire some of those elements of a profession that cannot be transmitted through textbooks.

Letters to the Editor

Cornish Engineers and the Steam Engine

SIR, Referring to your Impact note regarding the appeal of the Cornish Engines Preservation Society, there is one point which does not appear to be fully appreciated. (ENGNG., 14 July '61, p. 33).

As is well known, this county was responsible for developing the steam engine on the basis of Watt's famous separate condenser, but the engineers of Cornwall provided the world's first testing ground for the development of the Cornish steam engine.

From this historic work developed the knowledge and experience which provided the foundation for the world development of steam power. It is a simple fact, dimmed by time, that today the Watt separate condenser remains an essential part of all modern steam plant in every civilized country of the world.

The pioneer work of Cornish engineers gave Watt his great opportunity, and be it remembered that it was this pioneer work of the Cornish engineers that laid the foundation for the great age of steam power.

Yours truly,

JOHN D. TROUP.

Sanderstead, Surrey.
14 July, 1961.

Events in Advance

Physics of Semiconductors

A FURTHER international conference in the series on "The Physics of Semiconductors" is now being arranged and will take place at the University of Exeter from 16 to 20 July, 1962.

It is intended that this event shall follow the pattern of the previous sequence of conferences on this subject, which were held, respectively, at Reading in 1950, Amsterdam in 1954, Garmisch in 1956, Rochester in 1958 and Prague last year.

Next year's conference is being organized by the Institute of Physics and the Physical Society under the auspices of the International Union of Pure and Applied Physics and the British National Committee for Pure and Applied Physics of the Royal Society.

Accommodation at the forthcoming conference will be available for delegates in the Exeter University's halls of residence. Further information respecting the event may be obtained from the administration assistant, the Institute of Physics and the Physical Society, 47 Belgrave Square, London SW1.

Engineering in the Dairy

ARRANGEMENTS are now well in hand for holding a Dairy Engineering Exhibition in the national hall, at Olympia, London W14, from 28 January to 1 February, 1963.

The event is being sponsored by the Dairy Engineers' Association and is understood to be the only engineering exhibition in the United Kingdom which will be devoted wholly to the display of modern equipment for the treatment of liquid milk and the manufacture of milk products. It is intended that the exhibits shall include machinery, equipment and demonstrations relating to such matters as the reception, storage, pasteurization, sterilization, bottling and storage of liquid milk and cream. The production and packaging of cheese, butter, condensed milk and powered milk, as well as the production and packaging of ice cream, will also be covered by the exhibition.

Present intentions are that the event shall take the form of a trade show open to all persons concerned with the industry in any of its branches or with equipment used in the industry. Officials of government departments, educational and dairy research establishments, and students will also be able to attend.

Additional information can be obtained from the Dairy Engineers' Association, 14 Suffolk Street, London SW1 (telephone: WHItehall 0766), or from the organizers: Trades' Markets and Exhibitions Limited, 623 Grand Buildings, Trafalgar Square, London WC2. Telephone: WHItehall 1371.

Exhibitions and Conferences

Arranged in chronological order.

Iron and Steel Institute, Special Meeting in Canada and the United States.—Thurs., 19 Oct., to Tues., 7 Nov. Offices of the Institute: 4 Grosvenor Gardens, London SW1. Tel. SLOane 0061 (Provisional arrangements.)

Reactor Experiments and Tests, Symposium.—Mon., 23 Oct., to Fri., 27 Oct. Apply to the International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria. (*Venue not yet arranged.*)

Operational Research Society, National Conference.—Tues., 24 Oct., to Thurs., 26 Oct., at Leamington Spa. Offices of the Society, 64 Cannon Street, London EC4. Tel. CITy 1800.

Dairy Show, 75th Annual.—Tues., 24 Oct., to Fri., 27 Oct., at Olympia, London W14. Organized by the British Dairy Farmers' Association, 17 Devonshire Street, London W1. Tel. LANgham 6903.

Saigon International Trade Fair.—Thurs., 26 Oct., to Sat., 25 Nov., in Saigon, South Vietnam. Organized by the Saigon Chamber of Commerce, Tu-do Street, Saigon, South Vietnam. In the United Kingdom, apply to the Economic Department, Embassy of Vietnam, 12 Victoria Road, London W8. Tel. WEStern 3765.

Engineering in Plastics, Conference.—Mon., 30 Oct., and Wed., 1 Nov., at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London WC2. Organized by the Plastics Institute, 6 Mandeville Place, London W1. Tel. WELbeck 5439.

Fire Prevention Week, National.—Mon., 30 Oct., to Sat., 4 Nov. Organized by the Fire Protection Association, 31-45 Gresham Street, London EC2 (Tel. MONarch 7412) and the Royal Society for the Prevention of Accidents, 52 Grosvenor Gardens, London SW1. Tel. SLOane 2246.

Canadian National Packaging Exposition, Tenth.—Tues., 31 Oct., to Thurs., 2 Nov., in the Automotive Building, Exposition Park, Toronto. Organized by the Packaging Association of Canada, 1835 Yonge Street, Toronto 7, Ontario, Canada.

Effluent and Water Treatment Exhibition and Convention.—Tues., 31 Oct., to Fri., 3 Nov., at the Seymour Hall, Seymour Place, London W1. Organizers: Thunderbird Enterprises Ltd., 140 Cromwell Road, South Kensington, London SW7. Tel. FREmantle 4063.

Educational Problems of Nuclear Energy, Regional Seminar.—In November, at San Carlos de Bariloche, Argentina. Apply to the International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria.

British Equipment for Mexican Development: Fair.—Fri., 3 Nov., to Sun., 19 Nov., in Mexico City. Sponsored jointly by the Dollar Exports Council and the Federation of British Industries. Apply to British Overseas Trade Fairs Ltd., 21 Tothill Street, London SW1. Tel. WHItehall 6711.

Non-Destructive Testing in Electrical Engineering, Conference on.—Wed., 8 Nov., to Fri., 10 Nov., at the headquarters of the Institution of Electrical Engineers. Theme: "How Best May the Electrical Engineer Test the Quality and Endurance of His Materials and Structures?" Organized by the Measurement and Control Section of the Institution, in association with the British National Committee on Non-Destructive Testing. Apply to the secretary, the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London WC2. Tel. COVent Garden 1871.

Dairy Equipment Exhibition.—Wed., 8 Nov., to Tues., 14 Nov., in Paris. Organized by the Salon International de l'Equipment Laitier, 28 Rue Louis-le-Grand, Paris.

Building Exhibition, 29th.—Wed., 15 Nov., to Wed., 29 Nov., at Olympia, London W14. Organized by the Building Trades Exhibition Ltd., 11 Manchester Square, London W1. Tel. HUNter 1951.

Bonus to Britain of a Satellite Scheme

If Britain, France, Australia and perhaps other countries combine to build and operate a satellite launcher, there will be numerous benefits to the engineering industries.

AT STRASBOURG earlier this year, a number of European countries met in response to an Anglo-French invitation to discuss the feasibility of setting up a European-Commonwealth organization for the development of satellite launchers.

Proposal

The conference took as its starting point a comprehensive Anglo-French proposal for an initial project involving a three-stage rocket incorporating the British Blue Streak as its first propulsion stage and a French liquid propelled rocket as its second. A hypothetical third stage and payload, based on current techniques employed at the Royal Aircraft Establishment, Farnborough, enabled the expected overall performance to be assessed and discussed. No specific suggestions were made at the Strasbourg conference for the design and development of the third stage rocket and its initial payload—a simple form of satellite instrumented to measure the smoothness and accuracy of injection into orbit. One of the most urgent tasks before the European Organization will be to decide who is to undertake the uncommitted aspects of the launcher development.

One of the guiding principles of the United Kingdom in its approach to heavy rocket development for satellites has been to use existing equipment and facilities wherever possible in order to minimize cost. Thus the use of Blue Streak as the first stage rocket is essential to the proposal, and the same argument applies to the rocket ground testing and development facilities at Hatfield and Spadeadam, in England, and the launching and other range facilities at Woomera, in Australia. The French too have built up an extensive national programme and the use of facilities at Vernon and Colomb Bechar plays an important part in the development of the French rocket.

Performance Requirement.—To be really worthwhile over an extended period of time, a satellite launching system must satisfy the needs both of pure scientific research and of global communications as regards satellite weight, and the height and shape of the orbits attainable. Global communications require the placing of payloads weighing a few hundreds of pounds into circular orbits at several thousand miles altitude, whereas a comprehensive scientific research programme would probably be better served by a range of requirements which can be summarized as follows:

(i) A large satellite weighing between 1,000 and 2,000 lb in a circular orbit of low altitude; this satellite could be space-stabilized for astronomical observation;

(ii) a smaller satellite weighing several hundred pounds in an eccentric orbit going out to two or three earth radii, for the investigation of the earth's gravitational, magnetic and radiation fields, and the constitution of the earth's outer atmosphere;

(iii) a small satellite of about 100 lb weight, reaching out to about 100,000 miles in a highly eccentric orbit to study the sun's atmosphere.

Launching Vehicle.—These widely differing requirements necessarily lead to different performance requirements in the launching vehicle, but by careful design it is possible to arrange that only the third propulsion stage need be varied to meet the different performance aims. Briefly, a lighter payload allows the carriage of more fuel in the third stage and so the final velocity can be increased. This principle allows the first and second stages to be fixed in design and yet results in a launcher with a quite flexible overall performance.

The first stage, Blue Streak, 10 ft in diameter and 70 ft long, stripped of the equipment associated with its former military role, requires modification only of its topmost bay, to allow the second stage rocket to be fitted instead of a warhead. A useful improvement will be the uprating of its two engines to 150,000 lb thrust each. Blue Streak has no fins or wings of any kind, steering being accomplished by tilting the engines, known as engine gimballing. Since there are two engines, symmetrically placed at the rear of the rocket, roll pitch and yaw control can all be achieved by applying appropriate commands to the engine gimballing mechanisms.

After take-off the three-stage rocket, weighing just over 100 tons, will rise vertically for 20 seconds, climbing steadily to about 2,000 ft. It will then begin a slow turning over motion which will last until the desired trajectory angle, about 30° to the horizontal, is reached. Its speed at this point will be 2,500 mph, and its height nearly 18 miles. The third and last phase of Blue Streak's task then begins; it will accelerate up a straight climb path until its speed reaches 8,500 mph and all its propellents are burnt. The time from launch when this happens will be about 160 sec; its position 50 miles high, 80 miles down range. At engine cut-off the ignition process of the second stage rocket will be started and it will then draw clear. The spent Blue Streak will fall in a ballistic path on its return to the surface, landing almost 1,000 miles down range.

The French second stage will make use of techniques currently under development in that country. It will be propelled by a single chamber rocket engine burning nitrogen tetroxide and unsymmetrical dimethylhydrazine; if operated at sea level it produces a thrust of 25 tons. The supply of propellents to the thrust chamber is provided by pressurizing the main propellent tanks. The total stage weight is just over 8 tons of which about 85 per cent is propellent. The diameter of this rocket is 6 ft, length just under 22 ft and it will take about one minute to consume its fuel. The main engine is gimballed to give pitch and yaw control; roll control is achieved by means of auxiliary jets mounted at the top of the vehicle. The second stage also carries equipment for starting its engine on separation from the first stage, for the initiation of the second/third stage separation sequence and rate-gyros for auto-pilot stabilization during the period when the second stage is propelling the rocket.

When the second stage first begins thrusting, the Blue Streak falls away, its speed is already 8,500 mph and its particular job is to increase the speed to 14,500 mph along a straight line in space. This speed will be reached when the rocket is 250 miles down range and at a height of 105 miles. At this point the second stage will hand over to the third stage and begin the long fall back to earth. What is left of it after re-entering the atmosphere will land about 3,000 miles down range from the launcher.

When the third stage takes over, the rocket will be travelling at 14,500 mph at 105 miles high and still climbing, but when this stage completes its mission the satellite must have been given orbiting speed and be at orbit height, moving horizontally to the earth's surface for a circular orbit or climbing at the appropriate angle for an elliptical orbit. The final speed will be between 17,000 mph for a low circular orbit and 24,000 mph for highly eccentric elliptic orbits.

There are several designs of third stage which can be considered, but in general they fall into two categories, those where the third stage engine closes down for a period, allowing the rocket to coast up to, or almost up to, orbit height and then supplies the necessary velocity increase required to put the payload into orbit; and those where the third stage engine thrusts for the whole time but at a very low power for most of the way. There are also several combinations of fuel and oxidant, from the fairly conventional hydrogen peroxide/kerosine to the more powerful liquid hydrogen/liquid oxygen. Whichever is ultimately selected after a careful balance of such factors as payload weight, orbit and development time scale, it is necessary to incorporate an element of flexibility into third stage design such that payload weight and fuel can to some extent be exchanged and different missions accomplished without a need to change the basic rocket structure.

Among important subsystems in the vehicle are: telemetry in all stages, to relay vehicle internal performance to the ground; radio guidance equipment in the third stage; and range safety receivers in all stages to receive destruction signals if the vehicle should develop a fault causing it to swing off course. Inertia guidance has been rejected in favour of radar guidance.

It is a basic requirement of range safety for rocket launchings generally that the debris which falls to earth should be as harmless as possible.

To ensure reliability, all the essential radar trackers, computers and command links are at least duplicated.

Payload Capabilities.—For the optimum configuration discussed at Strasbourg, based on Blue Streak uprated to 300,000 lb thrust, the French second stage and a hypothetical hydrogen peroxide/kerosine third stage, a satellite of 2,200 lb may be put into a 300 mile circular polar orbit. Corresponding payloads for elliptical polar orbits, both with perigee heights of 300 miles, and apogee height of 7,000 and 100,000 miles, are respectively 940 lb and 320 lb. For a high altitude circular polar orbit at 5,000 miles altitude, a payload weight of 500 lb is calculated for this rocket combination.

An improvement in these payload weights could be obtained by using liquid hydrogen/liquid oxygen propulsion in the third stage. Development time would necessarily be longer than that of an hydrogen peroxide/kerosine design. Studies indicate that payloads of 3,400 lb and 1,400 lb would then be attainable for the 300 and 5,000 mile circular polar orbits using Woomera as the launching station.

Facilities.—The programme of development proposed at Strasbourg is planned to make full use of the rocket development and test facilities already created in the United Kingdom, France and Australia.

In England, at Hatfield, a test site set up for Blue Streak is well equipped for such tests as full scale investigation of liquid-propellent fuelling techniques, fuel-flow tests, control-system/structure-interaction investigations, and full-scale evaluation of vehicle/launcher dynamics at release. At Stevenage, the main assembly works for Blue Streak is well equipped with workshops and laboratories for a wide range of system testing. Spadeadam Rocket Establishment, near Carlisle, is a large facility equipped for the development and testing of large liquid propellent engines, and components, as well as the static testing of complete Blue Streak vehicles and ground support equipment.

In France, the necessary facilities for manufacture and testing of the second stage already exist or are being installed for the national programme. In particular, at the Laboratoire de Recherches Balistiques et Aerodynamiques, at Vernon, near Paris, facilities exist for testing the proposed propulsion unit and additional test stands are under construction. The Etablissement Aeronautique at Toulouse is equipped for structural testing, including simulation of kinetic heating. A laboratory for environmental testing has been set up at Cannes in addition to the many existing facilities.

Launching facilities for the second stage rocket will soon exist in North Africa, south of Colomb Bechar. Optical and radio tracking equipment, together with telemetry receiving stations, are being installed. The rate of development of the range is compatible with the proposals which have been made.

The facilities built up at the Weapons Research Establishment range at Woomera, and the advanced state of readiness of the Blue Streak launching area in particular, make the Australian range the obvious choice for the testing of the complete multi-stage satellite launching vehicle. In the Blue Streak area, the launching pad complex is nearly complete, supported by an extensive data processing and analysis facility. In addition there is a satellite tracking and recording station in current use.

Applications

The proposed launcher would, in its initial form, be capable of putting a satellite weighing 2,200 lb into a 300 nautical mile circular orbit, or a 500 lb satellite into a 5,000 nautical mile circular orbit. The proposed plan calls for ten launchings over the next five years, the last three being capable of putting payloads into orbit.

If the manner is examined in which satellites which could be put into orbit by the launcher could be employed the following main divisions are recognised: scientific research, communications, navigation and meteorology. A programme to put a man into space is not under consideration. In the scientific field there would be close cooperation with the proposed European Space Research Organization (ESRO).

A medium term programme is likely to commence in about four years time. A wide range of experiments would be initiated which would probably include the study of some of the following: (*a*) the ionosphere; (*b*) the energy distribution in the sun's radiation spectrum; (*c*) investigation of corpuscular radiation in the vicinity of the earth; (*d*) fundamental problems in long distance communication by means of satellites; and (*e*) the earth's gravitational, electric and magnetic fields.

The proposed launcher's large payload capacity would mean that on some occasions it would be possible for a number of experiments to be placed into orbit at one launch. Where an experiment might only require a payload of a few hundred pounds in a near earth orbit it is likely that a less powerful launcher such as Scout would be used. Polar orbits would be suitable for all the proposed experiments. As part of the medium term programme, a series of deep space probes would possibly be undertaken. These could commence in about five or six years time and would permit the detailed study of interplanetary space.

The ESRO long term programme is likely to include the larger and very complicated satellite projects. The proposed launcher would be available for this programme and satellites with weights of up to 2,000 lb might be employed. At present, man's knowledge of astronomy is restricted since stars and other heavenly bodies are known mainly by their light, which is partly absorbed by the atmosphere before reaching the earth. Satellites at an altitude of 300 nautical miles would enable more detailed observations to be made. Also suggested is a twin satellite experiment for radio interferometric studies and investigation of the upper atmosphere.

Of importance to many diverse fields of human activity is the use of satellites for meteorological purposes. The United States with their satellite Tiros II have demonstrated the feasibility of using TV cameras from satellites to photograph cloud formation over wide areas. Currently, the results of their first experiments are being analyzed by the US Weather Bureau.

Finally, a system using earth satellites, whose positions would be known accurately as functions of time, could be used for navigational purposes. Navigational satellites could form a complementary part of a VLF (Very Low Frequency) system being developed at RAE for world wide navigational coverage. Positions taken at intervals from the satellites would be used to cross-check the continuous information supplied by the VLF stations.

Although the possible uses of satellites have been covered separately, it is conceivable, where orbits are suitable, that one satellite could provide more than one service (for example, a navigation-meteorological satellite), thereby providing a more efficient and economic utilization of the costly launching process.

Benefits

The scientific and engineering problems involved in satellite launcher development require the evolution of new techniques in a wide range of technical and engineering disciplines.

These are not just improved versions of old techniques, but fundamental advances in order to surmount completely new problems. Components have to exhibit reliability for long durations, such as has never before been required, so that a whole new science concerned with reliability is being created.

Materials.—Rocket engine design requires low structure weight combined with high strength and resistance to very high temperatures and to corrosion by chemically active liquids and gases. New techniques are being developed for welding and brazing difficult alloys, and for fabrication of intricate shapes by flow turning and explosive forming. Refractory materials are needed for high temperatures; special insulating materials, seals and alloys are required to withstand the low temperatures of liquid oxygen and liquid hydrogen. For the fabrication of rocket tanks new methods have been developed for welding special high tensile stainless steel in the form of extremely thin sheet.

Surface coatings that can withstand extreme conditions have applications throughout the process industries.

Cryogenic Engineering.—In the development of liquid propellent rocket engines liquid oxygen and, in the future, liquid hydrogen, must be produced and handled on a large scale. This requires new types of structures, valves and pumps, and new instrumentation techniques. These, together with novel lubrication systems, control valves and pumps, derived from rocket engineering, are already finding applications in the metallurgical and chemical industries.

Combustion Processes.—The combustion process in liquid rocket engines is extremely complex. Achieving high stability and efficiency of combustion in the rocket engine is highly critical; experience shows that combustion research must include large-scale work, applicable in many fields.

Electronics and Instrumentation.—The supply of miniaturized and ultra-reliable equipment is essential both for the satellite and for the launching vehicle. In the latter the control, guidance and telemetry systems involve high-performance electronic and servo-mechanism devices, with particular emphasis on feedback techniques, which must operate satisfactorily in conditions of severe vibration and noise in the proximity of large rocket engines. Since the failure of one component may waste the entire launch, there is a unique incentive to develop reliable components and systems. Launcher and satellite work is already acting as a stimulus to the development of better and more compact forms of data storage, with a capacity ten to a hundred times greater than magnetic tape.

The application of automatic control methods will have special significance in steel mills, paper mills and in chemical engineering.

High Vacuum Conditions.—There is thus a stimulus to the provision of equipment on a fairly large scale for the study of these high vacuum phenomena and to discover methods of making bearings not requiring normal lubricants and having a very long life under such conditions. The basic physics of clean metal, semi-conductor and dielectric surfaces will be assisted by these studies, which will have repercussions in all those fields connected with high vacuum conditions, such as the thermionic valve industry. The availability of very high vacuum equipment "off the shelf" should result in advances in both pure science and engineering.

Power Sources.—Many of the engineering problems in the direct conversion of heat energy into electricity are similar to those involved in rocket engine design. Novel propulsion systems, such as the ion plasma type, pose similar problems and would in themselves provide an incentive for the production of a direct conversion system, of high efficiency and with no rotating machinery. Work on nuclear rocket engines, following that on liquid hydrogen engines, would supplement and extend research on ground-based high temperature reactors and direct conversion systems.

Conclusions.—From the above examples it will be seen that launcher and satellite technology is a highly sophisticated and stimulating branch of engineering. That the impact it can have on development of engineering skill and economic wellbeing in any complex industrial country must be enormous can be judged from the tremendous developments which the powerful stimulus of aeronautical research and development has brought about in other industries in the last few decades. The knowledge gained from such research and development includes, firstly the short-term extension of knowledge in known fields, such as some of the examples above, and secondly, the new discoveries which are unknown and unsuspected at the beginning of the programme. The latter are almost always the more important in the long term, because they lead to major technological advances. The full extent of technological benefits which are likely to stem from satellite launcher development cannot be predicted, but it is certain to be a powerful stimulus to invention and discovery.

Organization

The proposed Organization would be based on the Anglo-French proposals discussed at Strasbourg which provide for the setting up of an international Organization to develop and produce satellite launchers. A series of satellite test vehicles would be developed to prove the efficiency of the launcher. The successful development of a three stage launcher using Blue Streak as a first stage is expected to take about five years.

The Organization would be controlled by a governing body on which each of the participating governments would be represented. Each of the member states would have voting powers on this governing body.

The staff of the Organization would be an international body composed of individuals drawn from each of the member states.

Contracts.—Work would be carried out on behalf of the Organization by means of contracts placed either by the Organization itself or by the governments of member states, on the basis of a rational distribution of work among member states, having regard to technical and economic criteria.

Arrangements would be made for technical information acquired in the course of any project to be freely exchanged by member states. This would enable all countries joining the Organisation to enjoy the scientific and commercial benefits that could arise.

Finance.—It is estimated that the cost of the first programme to develop a three stage launcher based on Blue Streak with a French rocket as the second stage would be about £70 million spread over five years. Member states would contribute on a basis of their national income.

Cooperation.—The closest cooperation would be maintained with the projected European Space Research Organisation proposed at the conference at Meyrin in December, 1960, for collaboration between European countries in carrying out scientific research into space. It is envisaged that ESRO, which would not itself engage in the development and production of launching vehicles, would wish to use those produced by the European Launcher Development Organization.

Ferrari GP Successes due to Foresight

The new Formula One and Intercontinental Formula have caused the racing car manufacturers to think radically again. Those who took early action are now successful.

By Brian Lister

SINCE the new 1½ litre "weight limit" formula came into practical effect at Monaco in May, British cars have won only one Grande Épreuve. This was the Monaco Grand Prix, run over the short round the houses course of the Principality. The race was won by Stirling Moss in one of last year's Lotus GP cars fitted with a twin overhead camshaft 4-cylinder in line Coventry Climax FPF Mark 2 engine, which is similar to the engines used previously in British F2 cars.

There is little doubt that this is the only circuit where a British GP win is likely this year, assuming that the Formula 1 Ferrari's are present and in going order at the other Grande Épreuves.

The win on the difficult circuit at Monaco was largely due to the outstanding driving ability of Stirling Moss. In 1958 Vanwall won the world manufacturer's Grand Prix car championship, and in 1959 and 1960 it was won by Coopers. The last three years were the only time that Great Britain has had any success in first division motor racing.

TWO NEW FORMULAE

GP formulae change about every five years and when the new 1961 formula was announced late in 1958 (after the Vanwall victory) it was greeted with cries of hostility by British drivers and manufacturers. They felt that the proposed formula was not safe or spectacular, and they did not wish to change a formula we were winning. With the subsequent wins of the Cooper Car Company Limited in 1959 and 1960 there was an increased build up of resistance against the acceptance of the formula by British Formula 1 participants. Up to a year ago there were few British drivers or constructors who were really convinced that it would ever come into existence.

It was suggested by our representatives at the CSI that we would not accept the new formula at all, and that the old 2½ litre no weight limit formula should be continued—this was refused. It was then suggested that the weight limit should be removed altogether from the new formula; this again was refused. But last year a compromise was worked out whereby 50 kg (110 lb) was removed from the weight embargo of 500 kg.

An additional formula was introduced called the Intercontinental Formula. This was to be the same as the old Formula 1 but allowed engines of up to 3 litres capacity. The British drivers based their main resistance to the new Formula 1 on the grounds that the cars were not as safe as the 2½ litre formula. While the layman driver may consider that there can be too much power for safety, the racing driver takes the opposite and correct view that the more power there is available the easier the car is to control if driven well.

The reason is that most modern racing cars, and most production cars, understeer. Thus the slip angle of the front tyres is greater than that of the rear tyres. Alternatively, the front end would drift towards the outside of a corner if that corner was taken at a sufficiently high speed. Therefore if there is excess power the rear wheels can be made to drift a similar amount by the application of the throttle. The car is then finely balanced and is cornering at the highest possible speed, with all four wheels drifting.

If a corner is approached too quickly and the front end drifts out too far, the driver, if he is sufficiently skilled and has excess power, can usually spin the car, by application of too much throttle and locking the front wheels over thereby normally staying on the road and slowing the car down in the process. Drivers claim that this would not be so easy with lower powered cars of approximately the same weight as the older vehicles. Both these points are true to some extent. But it is interesting to observe that the fastest lap by the quickest new F1 car at the very fast Spa circuit, was only 4 per cent slower than the quickest old F1 lap. Spa abounds with fast curves that must be taken in four wheel drifts.

QUICK OFF THE MARK

While the British competitors were debating the new formula and considering whether it would ever come into effect, and later whether the Intercontinental Formula would be more successful because it may be faster, Ferrari and Porsche were getting on with the job of making cars for the new class. Porsche, of course, had an almost ready made Formula 1 car, they had for years been racing 1½ litre sports cars, and also during the last two years, Formula 2 cars. These were similar to the 1961 Formula 1 machines in specification. It is most surprising that Porsche have not done better this year so far. However, they have a new engine under development. This was expected to make its debut at Rheims for the French GP, but it did not appear.

It has been noted that Porsche Formula 1 cars have not been handling as well as the Italian and British cars on fast curves.

Enzo Ferrari on the other hand prepared a completely new motor car after experimenting in Formula 2 racing in 1960. As a result of these experiments and his observations of British cars he decided finally on a rear engine position. I have explained in an earlier article how this revolution can be traced back to Coopers. Last year Ferrari in his Formula 2 cars was using a 60° V6 engine, the same engine was used in the new car by Phil Hill and von Trips finished 3rd and 4th respectively at Monaco. The other Ferrari works driver, Ritchie Ginther, was using the latest Ferrari Grand Prix engine, this is the new wide angle 120° unit and is said to develop 190 bhp at 9,500 revolutions. At Monaco this car finished 3·6 sec behind Moss in his Lotus.

It should be emphasized that Coventry Climax and BRM have 1½ litre V8 engines under development, but neither organization has run one in a race so far this year. Rumour has it that we must wait until September before we see the Coventry Climax V8 engine in use.

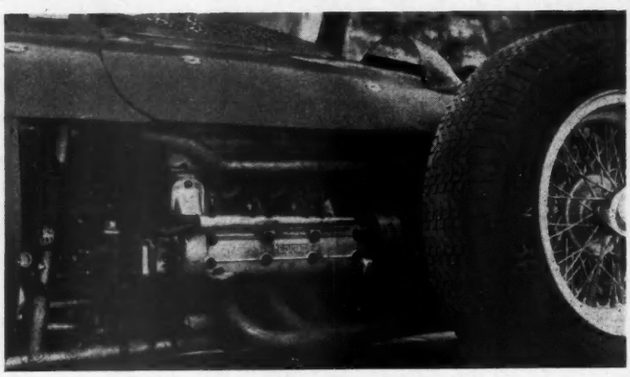
The second round in the world championship was held at Zandvoort in Holland. Here Ferrari had three cars with his latest 120° wide angle engine and they finished in 1st, 2nd and 5th positions. The third round was the Grand Prix of Belgium held at Spa, and once again on this very fast circuit Ferrari's won, Phil Hill being the winning driver this time with von Trips and Ginther in 2nd and 3rd positions and Olivier Gentepien in one of the 60° angle engined cars finished 4th.

Practice times at Rheims showed just how far ahead Ferraris are. The slowest of the "works" cars in practice was Ginther's 2 min 26·8 sec. The fastest of the other makes who did not take advantage of the Ferrari slipstream was Graham Hill's BRM, 2 min 29·1 sec.

In the race the Ferrari team suffered mechanical trouble with two cars and the United States driver Phil Hill spun and was delayed because he had to push start the car. The whole team was therefore virtually eliminated. However, the new Italian star Baghetti won in a 60° engine Ferrari which was privately entered, after a stirring duel with the "works" Porsches.

BETTER COORDINATION

We can partially blame the expectations and procrastinations of the British constructors and organizers for this state of affairs. But is this the whole story? Personally, I do not think that it is. For some time I have held the view that we need several small factories in this country similar to Ferrari's. An organization employing some 200 to 300 men, where it is possible to design and build a car completely within the factory, including all the pattern making, castings, forgings, machining, grinding, heat treatment, sheet metal and panel beating work, product finishing and inspection and assembly.



The new V6 Ferrari engine set at 120° has made a successful debut this season in the new Formula 1.

There is no doubt that the Rubery Owen organization, which makes the BRM cars, is able to cope with all these processes, on the other hand it is not done under one roof. And therefore getting the various processes through on time is likely to be just as cumbersome as if they were sub-contracting part of the work out. Cooper and Lotus only make a few parts for their cars. They sub-contract out much of their machine work and even some of their fabrication work. They also rely, of course, on Coventry Climax to produce engines for them on time, and who in turn sub-contract some work.

The difference, therefore, between the Ferrari organization and our own participants is that where the Italian factory can have a design from the drawing board to the racing circuit within six months, it takes British competitors two years. There is no doubt that we have the necessary designers in this country, and the skilled craftsmen—they have the enthusiasm to produce a race winning car quickly. The drawback is that we have not got them in one or two tightly knit teams. I believe this is a national problem and if we had a few small factories capable of developing racing cars and other experimental equipment very quickly, it could help British industry generally. The time saved on all kinds of prototype work would be enormous and viewed more widely it could mean British equipment being offered on export markets before that of our competitors.

Human Element

Better Design of Electrical Appliances

A NEW research fellowship worth £750 a year, possibly the first of its kind, is to be awarded at the Royal College of Art by the English Electric Company next year. The offer is being made to enable young designers to work more closely with the manufacturers of domestic electrical appliances in the task of translating creative ideas into practical use on the production line.

The award will allow the successful candidate to carry out research in the design and use of electrical household appliances as a post-graduate project for one year.

A sum of up to £150 will also be awarded each year to those students who, in the opinion of a committee composed of three members of the College staff and three from English Electric, have produced the best designs. The £750 fellowship will enable the best student in this group to do a post-graduate year of research in cooperation with the company designing domestic appliances for the future.

To aid these young designers, the company will give them experience of working in industry and will put at their disposal the resources and professional advice of the domestic appliance division. Schemes which combine practical experience with industry and academic studies have already met with considerable success both in the company's post-graduate fellowships and in their engineering apprenticeships.

Commenting on the awards, Mr. H. C. Timewell, general manager of English Electric domestic appliance division, said "We are most encouraged by the growing insistence on good design by our customers both at home and abroad, and we hope the arrangements we have made with the Royal College of Art will in turn encourage able designers to think seriously of using their talents in our expanding industry."

Cave Exploration Beneath the Mediterranean

Fifteen members of the Cambridge University Underwater Exploration group are sailing from Poole Harbour, Dorset, on the motor yacht Titania for the Mediterranean, where they are to undertake four months of underwater archaeological research.

Using a technique recently developed at Cambridge, the principal scientific objective is to make a new set of readings of the Mediterranean sea level, recording changes since the early ice age.

The Titania, a 138 ton twin-screw diesel yacht, will be the home of the expedition members for the next four months. She carries Marconi Marine radar and two Marconi Ferrograph "Offshore" echometers which will primarily be used for navigation, although one echometer is a portable model for use in plotting cross-sections of underwater caves.

It is hoped that exploration and excavation of more than forty sunken caves will provide useful scientific information. Using radioactive carbon it may be possible to find an estimated date for when the caves were last on the surface.

Information on sea level changes should give new light on the possibility of future movements in sea level which could affect low-lying countries and the fortunes of present day sea ports.

Among the organizations and private individuals supporting the expedition are Sir Edward Bullard, F.R.S., Professor Toynbee, the Royal Geographical Society, the National Institute of Oceanography, and the Department of Scientific and Industrial Research.

Changing Habits in British Air Travel

For many years since the war the tendency has been for advance holiday booking to become more and more advanced. Families who once spent happy hours in March evenings deciding between Cornwall and the Costa Brava took to doing so in January and then even advanced their planning to October and November of the year before.

Now British European Airways are finding that these winter holiday planning habits are being abandoned, at least by a proportion of travellers.

A recent survey conducted by the airline has found that far from the head of the household making his plans up to twelve months ahead of time he is now more than likely to leave making the arrangements with BEA until within three months of the hoped for departure.

As many as 50 per cent of their travellers do this now and there are another 25 per cent of intrepid individuals who leave getting in touch with BEA until the last month before they intend to go.

Last Minute Seats

How much does this development upset the booking system?

Whether by coincidence or not the trend has turned in this way at a time when leading air operators are showing the way in installing computer equipment to speed up, and improve the flexibility of their booking offices. There is also, to put it conservatively, plenty of space on many services, the problem for some airlines being not how to fit all the passengers in but how to sell all the available capacity.

BEA explain that holidaymakers making up their mind at the last moment should still have a good chance of finding seats on routes to centres on the Continent for which the demand is steady.

Among these are Corsica and Sardinia, Geneva, and in Scandinavia—Copenhagen, Stavanger, Gothenburg and Stockholm. Klagenfurt and Vienna in Austria and Palermo in Sicily are among places where the late booker should be able to get seats.

Two distinguished aircraft have sharply added to BEA's passenger capacity. Replacing the Viscounts, they are the 86 seat, 525 mph pure-jet Comet 4B and the 113 seat, 425 mph turboprop Vanguard.

For the moment the bus-service, first come first served, style of operating aircraft is left to certain enterprising operators in the United States. With increasing capacity, better equipped booking systems and above all, the willing cooperation of the public, such a change may not be so long delayed on services from and within the United Kingdom.

Noise from Building Sites

The National Federation of Building Trades Employers has obtained the views of a number of its members, mainly the larger contractors, on the types of building and contracting plant that cause most public complaint in respect of noise and on the steps that can be taken to minimize noise.

These views have been incorporated in a memorandum which the Federation has submitted to the Government Committee sitting under the chairmanship of Sir Alan Wilson, F.R.S., on the problem of noise. Representatives of the Federation have also given oral evidence before the Committee.

The Federation's memorandum states that although a contractor may take every possible step within his power to minimize noise, it must be appreciated that a certain amount of noise is bound to occur in constructional work.

The memorandum continues "Contractors working in close proximity to occupied residential and commercial property realize that they have a duty to carry out their work with as little noise as possible. In such cases they will often communicate with the neighbouring occupiers and so far as possible consistent with their contractural obligations, will endeavour to meet their wishes."

The memorandum closes with the following conclusions:—

1. Many forms of building operations and items of building equipment are noisy and give rise to complaints from time to time.
2. Being required to carry out a particular design, the builder has comparatively little choice in the type of equipment or method of operation he can use. In certain instances it may be possible to use alternative methods of construction which are less noisy, but these will normally be more expensive and the client may not be willing to bear the extra cost.
3. Noise which would be unnoticed during the day can become intolerable at night. Night working, however, is not common. Where it is necessary, it can sometimes—but not always—be so arranged as to leave a quiet period.
4. Contractors are continually seeking to reduce noise by making modifications to existing plant, but the effectiveness of such modifications is necessarily limited.
5. The reduction of noise through better organization of the site is often precluded by the restricted nature of the site.
6. It would appear that the solution of the problem of noise in constructional work depends rather upon the production of newer types of plant which are less noisy in operation than upon improvements in the methods of operating such plant. The efficiency of less noisy plant for the purposes for which it is required and its comparative cost must, however, be taken into account.

Landscaping Trunk Roads

The Minister of Transport has appointed Mr. M. R. Porter to fill a new post of Landscape Architect in the Ministry. The post arises from the increasing amount of work falling on the Minister's advisory committee on landscaping trunk roads because of the acceleration of the road programme.

Mr. Porter is 35 years old and was educated at Bedford School. He studied landscaping architecture at Reading University, and he is an associate member of the Institution of Landscape Architects. He was previously responsible for landscaping at Basildon New Town.

Power and Salmon Reconciled

Speakers at a recent annual meeting of the Engineering Institute of Canada devoted very serious attention to the side effects of hydro-electric power development and formulated ideas for safeguarding British Columbia's valuable salmon resources.

Two contributors to the discussion, Professors J. F. Muir and Eugene Ruus, of the Department of Engineering at the University of British Columbia, presented a paper in which construction of a 100 ft dam on the Fraser River is advocated.

They believe that at least one dam can be constructed on the Fraser with a minimum of interference with the migration of young and adult fish, and urge a coordinated research programme to solve the "fish versus power" problem in B.C.

They suggest that a dam near Spuzzum, 120 miles from Vancouver, would permit a hydro-electric development of 700,000 hp. The reservoir thus created would raise the water level in Hell's Gate Canyon and eliminate the obstruction to migration of adult fish through this difficult stretch of the river.

A Vancouver consulting engineer, Mr. Val Gwyther, argued the case for scientific handling of the salmon problem on a somewhat broader front.

"The present policy of retardation of power development in a watershed, due to our inability to produce the answer to fish migration is in the past, and these watersheds are now open to development of both fish and power," he said.

Mr. Gwyther's paper goes at length into the problems of fish propagation. Rearing capacities of natural and impounded lakes, he maintains, should be utilized by artificial fertilization and incubation of eggs to give a yield far in excess of that from natural spawning grounds.

Staff Conference on Work Study

A two-day conference on work study arranged by British Insulated Callender's Cables Limited is an example of the intensive training which is provided nowadays by many enlightened firms for their staffs.

Eight sessions have been arranged on 12 and 13 October, when a number of experts on work study and related subjects have been invited to give addresses. The aspects to be discussed will include organization, management training and the impact of the trade unions on business. Speakers' panels will cover such matters as work measurement in the office, the application of operational research techniques, the evaluation of commercial opportunities, methods-time study, and the study of modern methods generally.

Reducing Seepage Past Earth Fill Dams

Preventing seepage through or round earth fill dams involves constructing an impervious barrier within or on the upstream face of the dam and down to bed rock. Clay, cement grout, bitumen and now steel and plastics have been used.

SEALING earth and rock fill dams requires not not only the provision of a waterproofing element on the upstream face or in the interior of the embankment, but also the treatment of the foundation rock bed and adjacent hillsides. By such means is the seepage through, under and around the structure prevented or reduced to an acceptable flow.

The most common methods of providing a seal for the embankment itself are by a core of impervious material (of clay if available, or of bituminous concrete) or by laying a blanket, usually of bitumen or bituminous concrete, over the upstream face. Recently watertight steel facings have been employed with marked success, and a plastic membrane has also been tried. Sealing the surrounding and underlying strata may be accomplished by constructing a cut-off trench, filled with an impervious material which reaches down to sound bed rock, regarded by many as the best method, or by grouting the rock with a cement slurry so as to fill and seal the cracks; in addition, a reduction in flow through the foundation rock can be obtained by laying an impervious blanket upstream of the dam—this can rarely achieve a total stoppage of seepage by itself but it can have the effect of reducing the water pressure on the face of the cut-off trench or in the grouted rock.

AN INCREASING PROBLEM

Attaining a satisfactory seal under earth and rock fill dams was one of the four questions discussed at the Seventh International Congress on Large Dams held recently in Rome. Altogether 22 papers were submitted from European countries, including Great Britain, and from the USSR and the USA. In addition, at least another 18 papers dealt with allied problems but were considered in another of the technical sessions, that dealing with underground works.

A preliminary report of the Congress has already been given in ENGINEERING (30 June, p. 894) with summaries of a small selection of the 140 papers that were submitted. The following report is based largely on the General Reports on Questions 27 (Sealing of Earth and Rock Fill Dams) and 25 (Underground Works) and on the discussions that took place during the technical sessions of the Congress.

The importance of the sealing problem in earth and rock dams cannot be over-emphasized. Many, many dams, both for water power and conservation purposes, are having to be built in wide valleys and often above "soft" alluvial beds. Concrete dams in these conditions are not ruled out—indeed, many attempts are being made to extend design of concrete dams to accommodate the conditions peculiar to wide valleys—but more frequently the solution is to be found with earth and rock fill dams.

For the future, the largest dams will be of this type. In Africa, both the High Dam on the Nile and that on the River Volta in Ghana will be rock fill dams. In India, it has been reported that over 90 per cent of the dams are built in wide valleys, as opposed to the familiar gorge where concrete arch dam is more appropriate. In the USSR many of the big rivers are being controlled by earth dams, though there it is a regular practice to build a composite structure, with concrete used for the spillway and intake sections. In China, work on many of the big rivers will involve similar treatment.

In some areas, the otherwise usable water resources are located above pervious rocks. Yugoslavia is such an example. According to a paper given at Rome, 25 per cent of the water resources in that country, equivalent to 6×10^{10} kWh per annum, are found in the karstic region of the Dinarique Mountains draining towards the Adriatic coast. In such regions—and the problem is also to be found in many other areas—the construction of loss-free reservoirs means a virtual blanketing or grouting of the whole floor of the reservoir. No alternative exists if the water, which is there and "free," is to be fully exploited.

Choice of material for making the seal at any given site will depend on supplies. The existence of local beds of clay, which can be packed to form an impervious membrane, may resolve many of the problems; in contrast, cement and bitumen nearly always have to be carried to the site and it is a feature of most dams that they are not located in readily accessible places and, moreover, the quantities involved are liable to be very large indeed.

HIGH DAM CUT-OFF

Something of the magnitude of the problem in a really big dam is illustrated by the High Dam—Sadd-el-Aali—proposed for the River Nile. According to a paper presented to the Congress, the main barrier to seepage below the dam will be provided by a vertical cut-off curtain below the clay core and extending through the river bed as far as the bottom of the upper stratum of the overburden, a depth of 130 m (420 ft); in addition, grout holes will be driven through the lower stratum of the overburden to the bed rock, a depth approaching 750 ft. In the upper 85 m below the river bed, the thickness of the curtain is to be 60 m (200 ft); below this depth the thickness will reduce in stages to 30 m (100 ft). The width of the river bed at this point is about 2,000 ft.

It is believed that local clay deposits will be sufficient to construct this enormous curtain. For reasons of economy, as well as to facilitate injection, the possibility of grouting with clay alone was considered, but laboratory tests showed that Aswan clay by itself had little ability to resist being washed out by water under pressure. The addition of 1 per cent of silicate increased the cohesion of the grout fourfold and, moreover, was found to make the clay grout more fluid and to assist in settling the grout after injection. In some sections of the work, the overburden sand is very fine and here the grout mixture tried has comprised a mixture of silicate and aluminate or deflocculated bentonite. More than one speaker during the discussion referred to the beneficial effect that the addition of bentonite had on clay grouts.

In conditions of complicated faults of limited extent, grouting procedures are essential. For example, Guma dam to be built in Sierra Leone will be an earth fill structure 64 m (200 ft high) and a combination of cement and clay-cement grout will be used to form the cut-off curtain. The dam is located in a narrow fault valley in which weathering has produced extreme laterization. The primary treatment will comprise cement grout curtain with a maximum depth of 46 ft; this curtain will be augmented by multiple lines of clay-cement grout in the heavily laterized zones, particularly near the abutments.

UPSTREAM BLANKETS

The effectiveness of cut-off curtains and the installation of blankets to control abutment seepage was reported in a paper on the McNary and Chief Joseph dams in the USA. At the McNary dam, 160 ft high, a contiguous earth embankment ties the concrete structure into a pervious sand and gravel abutment on the left bank. Seepage control is obtained through an impervious upstream blanket 1,000 ft in length in conjunction with a downstream drainage collector system. Over the period of six years, the seepage has dropped from 150 to 100 litres per second; this drop is credited to the natural disposition of silt in the over-burden, so reducing the flow paths.

Increases in the effectiveness of upstream blankets with time was also reported for a series of dams on the River Missouri—again the improvement can be attributed to the formation of a silt layer, for the river carries a lot of sediment. Three of these dams also had steel sheet pile cut-offs and, as can be expected, these appear to become more effective with time due to silting and corrosion of the interlocks.

A Russian paper referred to the use of a concrete pile curtain used below the Churubia dam which, though only 70 ft high, is over 3,000 yd long. The thickness of the gravel varied from 20 ft to 130 ft. The individual piles were placed in holes drilled with cable tools and a positive seal with the foundation was obtained by drilling 18 in into the bed rock; the holes over-lapped sufficiently that edge contact between the piles was obtained but no details of the seal or the interlock, or of the seepage data, were given in the paper.

CHOICE OF BARRIER

The selection of the type and location of the sealing element for the embankment is dependent on several factors, including the height of the embankment, availability of local materials, adaptability to the foundation treatment, problems of importing materials, and the extent of the wave protection required. The scheme for reservoir operation also bears on this point, because the decision to use an impervious facing may be based on the opportunities available for periodic inspection during times of low water level. The need to use the upstream portion of the main embankment as a cofferdam for diversion of flood water may limit the location of the waterproof core to an interior position. Construction techniques, particularly on high dams, impose limitations on the type of seal used, since deflections and settlements differ markedly between embankments constructed by dumping and sluicing methods—one American speaker at Rome implied that sluicing was completely ineffective—and those constructed using vibrating rollers and other mechanical compaction methods. Above heights of 200 ft, settlements in embankments must be considerable, whatever methods are used, and the problem is to avoid cracking or disrupting the seal, whether it is an internal core or an external facing. The difficulties are greater with the external facing and the solution seems to call for a sheeting that is sufficiently flexible to accept movements involved without breaking the seal but, at the same time, the sheeting has got to be able to accommodate weathering, possibly under conditions that involve periods when it is not submerged and subjected to considerable temperature changes.

ACCOMMODATING SETTLEMENTS

Experience has shown that, properly mixed, bitumen and bituminous concrete can fulfil these requirements. For example, at Ghrib in Algiers conditions arose that enabled the membrane to be thoroughly examined after 20 years' service and it was found to be sound and apparently to have the prospect of a long service life. There the bituminous membrance had been laid over a porous concrete drainage layer and protected by an anchored reinforced concrete facing. The inadvisability of placing an asphalt skin on too steep a slope without a holding grid was illustrated by the failure of the facing at Pego do Altar where, due to the steepness and possibly bad mixing, local flow of the asphaltic concrete occurred at several points. A steel facing was later installed.

During the discussions an American speaker described the placing of the waterproofing skin

Corrosion Protection of a Service Main

At the port of Kingston-upon-Hull, the British Transport Commission, in conjunction with the user companies, are replacing an old timber jetty, built in 1914, by a new reinforced concrete structure.

To ensure that the new structure has a useful life at least equal to that of the one it replaces, and to reduce maintenance to a minimum, care has been taken to protect all the metalwork against corrosion. Of particular interest is the protection system devised for the 2,500 ft long 6 in spun-iron service main which carries fresh water from the shore to the jetty terminals, for ships' replenishment and jetty services.

The fresh-water main is heavily lagged against frost. To perform the double duty of protecting the pipe itself from corrosion, and the insulation from loss of efficiency due to the penetration of moisture, the lagging contractors, John T. Schofield and Sons Limited, of Burnley, have employed a wrapping system using Denso materials supplied by Winn and Coales Limited, London SE27.

The work of insulation and moisture protection is shown in its various stages in the illustration. In the foreground is the bitumen-painted pipe itself. The first stage of protection consists of Onazote expanded rubber insulation, 1½ in thick, applied in segments, which are tied in place with galvanized wire, the gaps being filled with an adhesive compound. The first layer of moisture-proofing consists of 4 in wide Denso tape, wound round the pipe and lagging in a spiral with a 2 in overlap, thus providing a double-skin covering. The tape material consists of an open-weave absorbent cotton fabric, richly impregnated and covered on both sides with a paste-like compound based on saturated petroleum hydrocarbons with a high resistance to the penetration of moisture. The addition of inert siliceous fillers gives body to the compound, while corrosion inhibitors neutralize the effect of any residual moisture.

Application of tape is simple, the material being fully workable at any temperature between 20° F and 110° F. It is unaffected by temperatures up to 130° F.

Further protection against moisture, and a greater degree of defence against mechanical damage, is provided by the addition of heavily bitumenized hessian tape, from the same supplier. This tape is 6 in wide and is spiral-wound with a 1 in overlap. It is wound on as tightly as possible, the effect of even moderate temperatures being to blend the bitumen into a skin which, however, will not soften unduly, nor drain off at the highest temperatures. In the region of joints and valves gentle heating with a blow-pipe ensures that bonding is complete.

It is expected that the efficient life of the protective system will at least equal that of the pipe's resistance to internal corrosion. In practical terms this means that, barring accidental damage, the system will outlast the pipework, without further expenditure on maintenance.

The bitumen painted pipe is protected by expanded rubber sections and bitumenized hessian.

Railway Electrification of India's Industrial Belt

With the setting up of steel plants at Rourkeda, Durgapur and Bhilai in the public sector, and the expansion of similar units in the private sector of Indian industry, the electrification of railways in these areas has become imperative to facilitate carrying of raw materials and finished products. The electrification of the tracks from Burdwan to Mogalsarai via Dhanbad on the Eastern Railway and from Asansol to Rowkela and Raj Kharsawan to Gna on the South Eastern Railway was completed in April, 1961.

For power supply to the railways, the Bihar State Electricity Board has constructed 160 miles of single circuit and 120 miles of double circuit 132 kV transmission lines, together with five 132 kV/25 kV step-down substations to feed the railway at 25 kV. The traction is single phase 25 kV at industrial frequency of 50 cycles per second, the track forming the return path. The single circuit transmission lines are mostly in the Singhbhum district in Chotamagpur. The line runs from Chandil to Rowrkela via Raj Kharsawan and Goilkera and from Raj Kharsawan to Joda via Chaibasa and Kendposi. The double circuit transmission lines are from Sone Nagar to Pipri (Rihard) and from Dalbhumgarh to Mosabhani. The substations are located at Raj Kharsawan, Kendposi, Goilkera, Dalbhumgarh and Karamnasa. All the substations receive power at 132 kV 3 phase 50 c/s from the grid to assure continuity of supply to the railways. The total estimated cost of this work was approximately Rs4 crores (£3 million).

The sections between Asansol and Sitarampur and between Sltarampn and Pradhamkhurta have the heaviest density traffic on the Eastern Railway, dealing with 38 million gross ton-miles per route mile per annum as compared with an average of only 8 million on the rest of the railway. It was reckoned that by the end of 1960-61 the traffic density here would have gone up to 46 million ton-miles per route mile per annum. The section draws electric power from a 132/25 kV substation of the Damodar Valley Corporation Authority near Kumardubi. A new route control centre has been set up at Asansol for controlling the power supply to the overhead traction equipment over the entire section from Durgapur to Gaya, electrification of which is under way. The 25 kV ac single phase 50 cycle system of traction for the section is the first of its type in India.

Concluding **Reducing Seepage Past Earth Fill Dams**

on the face of the Montgomery (Colorado) dam. This is the only dam in the Americas to rely on a bitumen membrane for sealing.

The diaphragm is 10½ in thick laid in three overlapping 3½ in skins, each 12 ft wide, by a conventional Barber Greene machine which was hauled up and down the face by ropes. The hot asphaltic concrete was fed to the machine in skips lowered from the crest of the dam. After four years there is no sign of cracking. The basic requirements for a sound asphalt membrane are a good mix, high density (adequate compaction) and, therefore, a low air void content.

Concrete slab facings have been used with success in France and their development has shown the importance of getting a good joint between the foot of the facing and the cut-off; this is made easier by moving the cut-off wall upstream away from the foot of the facing.

At La Sassiere, articulation of the concrete surface has been obtained by dividing the slab into rectangular sections. The vertical jointing is continuous from the crest to the cut-off, but the horizontal joints are adjusted in width to accommodate greater movements in the lower face. Field measurements of concrete faced rock fill dams indicate that expansion takes place near the abutments—suggesting heaving—and compression occurs in the lower central portion of the facing. It was also found that deflections normal to the facing were roughly proportional to the square of the height of the dam.

For economic reasons the individual slabs are made as large as possible to give the minimum of jointing compatible with absorbing the movements. Generally, the joints have been made using copper strips between the slabs, but at La Sassiere rubber water stops have proved satisfactory.

OUTSTANDING PROBLEMS

As already mentioned, successful use has also been made of steel facing and reports are also available on the use of a plastics membrane laid between two layers of corrugated precast slabs. The lower slab provides a bed on which to place the plastic sheet while the upper slab gives protection against abrasion. Service experience is not yet available to prove the effectiveness of such an arrangement. Where steel facings have been employed, stainless steels have been used to prevent corrosion or a bituminous coating has been laid over the facing to give protection against the weather. With the small settlements that have so far been experienced, the steel facings have not been subjected to high shearing forces, and they have proved both watertight and flexible.

Underlying the problem of sealing dams there is a need for more data. There is a difficulty about obtaining information in the laboratory because many of the characteristics being investigated are not amenable to scaling, so records from sites are essential to progress. Particular issues that were suggested for discussion at the Congress, and which can therefore be considered as requiring further investigation, are as follows:

1. The minimum thickness that can be accepted for earth cores in high dams, taking into account considerations of hydraulic gradient and differential treatment.
2. The allowable deflections that can be accepted for the different types of facing slab or membrane, as this affects the type of embankment construction for which the facing can be used and also limits the embankment height for which some types may be suitable.
3. The effect of ageing on bituminous concrete, with particular reference to conditions in which the facing is subjected to erosion and weathering.
4. The stability of bituminous concrete as an internal diaphragm for high dams—over, say, 200 ft.
5. The utility of vibrated rock fill under all types of facing slabs and as transition zones or as shells for dams with earth cores.

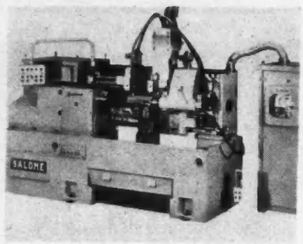
MULTI-TOOL AND COPYING LATHE

Programme Controlled

THE Salomé "Synchromat" has been designed to provide simplicity and flexibility of preselected automatic cycles, and in addition to copy turning and boring, it can be used for straight turning, drilling, boring, forming and facing.

The modular design of precision transverse and copying slide units together with a rapid "Plug-Board" setting for automatic programme control, are outstanding features. The vertical bed has two sets of hardened and ground steel slideways on which two carriage slides are mounted. Interchangeable transverse slide units are designed for fitting on both the upper and lower carriage slides. Two transverse slides may be fitted on each carriage unit. Alternatively, a copying slide unit may be fitted on the upper carriage slide in combination with a transverse slide unit arranged either to the left or right.

All the automatic and fine feed motions of the carriages, transverse unit and the copying unit, together with chucking and tailstock operations, are



hydraulically actuated and controlled by the "Plug-Board" according to the preselected programme sequence. Automatic spindle speed changes during the cycle are also programmed. The slide units may be operated in combined or successive sequences according to a preselected cycle. The headstock and spindle have a direct-coupled drive from a 15-25 hp motor, according to requirements. Two automatic spindle speed changes in the ratio of 3 : 1 are obtained with a single speed motor and four changes in the ratio 6 : 1 with a two-speed motor. *Dorman Machinery Sales Limited, Woodside Hill, Chalfont St. Peter, Buckinghamshire.*

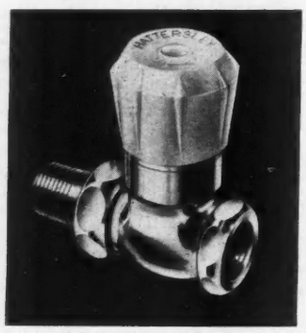
COMPACT VALVES

For Hot Water Systems

A NEW range of easily operated radiator valves is announced for use on all low and medium pressure hot water heating systems up to 150 lb per sq. in and 250° F.

These valves are known as the Hattersley Del*Flo type and are available in sizes from ¾ in to 1 in in both straight and angle designs. They feature hand wheels in a streamlined design and lockshields in ivory-coloured Delrin (Du Pont acetal resin). This thermoplastic material has unusually high qualities of strength, toughness and stain resistance and has an attractively translucent appearance.

The glands are permanently packed with Ptfe impregnated asbestos, this giving a smooth spindle movement and long service life. Bodies and tail parts are in cast bronze and can be supplied in natural casting finish, polished or chromium plated. The design is calculated to give minimum flow resistance in both straight and angle patterns. The latter features spherically seated discs for proportional flow control, and both



designs back-seat in the fully open position. In ½ in and ¾ in sizes the angle design will also be available with compression joint for BS 659 copper tube.

Wheel valves can be converted to lockshield valves or vice versa; the lockshield valves have a concealed indicator beneath the shield, to enable heating engineers to adjust them accurately. The design complies with BS 2767. *Hattersley (Ormskirk) Limited, Ormskirk, Lancashire.*

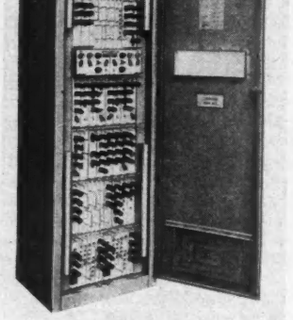
TIME-DIVISION MULTIPLEX SYSTEM

Error Detection

THE "Autoplex" equipment HU20 series is a time-division multiplex system with automatic error detection and correction, for higher accuracy in the transmission of radio-telegraphy.

This equipment is claimed to increase the traffic-handling capacity of any given route and to enable HF radio-telegraph networks and ionosphere scatter circuits to be connected into the International Telex system. The use of data-processing machinery and computers is possible at the receiving end with the "Autoplex" system, as no human inspection is entailed; any characters distorted in transmission are automatically queried by transmission back to the sending station. Retransmission of characters containing the queried one is then made and no human intervention is involved at any stage.

Standard 7-unit error-detecting code is employed. The system is synchronous, transmission speed being controlled by a highly stable crystal oscillator. The main terminal equipment illustrated here,



Type HU21, consists of narrow units in rows at the front and back of a single cabinet. *Marconi's Wireless Telegraph Company Limited, Chelmsford, Essex.*

SIDE-ENTERING MIXERS

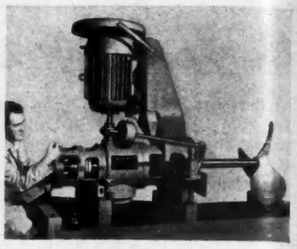
High Blending Capacity

INNOVATIONS in side-entering mixer technology applied to fluid agitation in process industries have been incorporated in the new Lightnin NSE mixer range. Blending capacity is stated to be much improved with this design, with significant reduction in installation and operating costs.

The new NSE mixer range offers a series of side-entering units in three basic sizes of applications, ranging from 1 to 50 hp, compared to the previous limit of 25 hp. The mixers are right-angle spiral bevel gear units with hollow quill speed reducers developed specifically for side-entering applications.

The addition of larger units to the side-entering range, plus the increased flow of these mixers, permits savings in initial investment. The manufacturers report that a single 50 hp Hi-Flo side entering mixer is capable of doing the work of three conventional 25 hp units, and that multiple unit installations may therefore often be eliminated.

An auxiliary range of side-entering



mixers (Series RSE) is also now available for installations not requiring the shock load protection afforded by hollow quill construction and independent bearing support, which is standard in the NSE line. RSE side-entering mixers are manufactured in two basic sizes ranging from 1 to 25 hp.

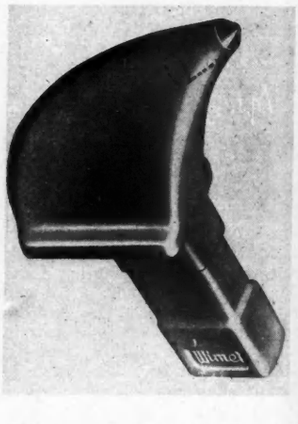
A new design of super-pitch propeller offers improved hydraulic efficiency on both NSE and RSE mixers. Standard sizes provide optimum motor loading for common operations, and an increased number of propeller sizes ensures suitable propeller selection for non-standard conditions. *Lightnin Mixers Limited, London Road South, Poynton, Cheshire.*

SHEARER PICK

Slug-Insert Beak Type

NOW offered for universal application on drum shearers is the Wimet slug-insert beak type shearer pick. This device, developed from trials in the East Midlands Division of the National Coal Board, is reported to have led to substantial reductions in power requirements together with an increase in the large coal content.

The initial tests with this form of insert took place in a colliery where the face had a cutting length of 138 yards, and was adversely affected by a fault of 2 ft displacement; the floor was hard and undulating. Since the introduction of the slug-insert beak shearer it has been estimated that a considerable reduction in the total number of picks used has been effected. The time lost in replacing pick discards has also been reduced, and ammeter readings taken during the cutting period showed that the machine was consistently operating at between 80 and a maximum of 90 amps as opposed to the previous rating, which was of 80 to 120 amps.



The manufacturers state that the tests, carried out by National Coal Board personnel, showed that 257 conventional type picks were discarded in cutting 8,418 yards, and in cutting 5,107 yards, 28 slug-insert beak shearer picks were discarded. *Wickman Limited, Banner Lane, Coventry.*

PRE-HEAT INDICATOR

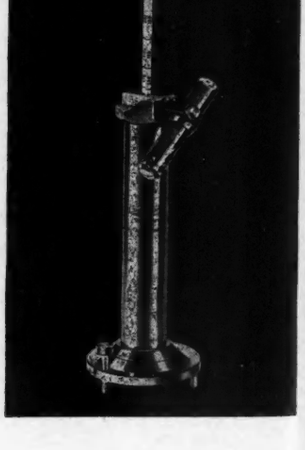
For Fuel Oil

THIS instrument permits a rapid and accurate on-the-spot test of fuel oil to determine the exact pre-heat temperature required.

It allows for variations in viscosity between batches of fuel oil which can cause excessive pre-heating.

The instrument consists basically of a steel cylinder approximately 1½ in in diameter by 9 in high, standing erect upon a special levelling base and fitted with a perforated plunger carrying the scale rod, which projects above the screw-top of the cylinder. The rod carries five separate scales, for atomizing viscosities of 75, 110, 155, 200 and 400 sec Redwood No. 1 respectively.

The sample is introduced into the cylinder and the scale rod lifted to its fullest extent, where it remains locked by a cam. The timer is then turned through 180° allowing the plunger to descend through the sample until the timer swings back to the locked position. *Shandon Scientific Company Limited, 6 Cromwell Place, London SW7.*



MOBILE CLEANING EQUIPMENT

For Pipelines

RAPID cleaning of walls and equipment and the removal of blockages in pipelines and sewers are possible using the "Atumat," a mobile high pressure pump unit which has been designed in Germany.

The standard equipment is suitable for cold or warm water jets, and special equipment is available to deal with hot water and sand-water mixtures. Solutions containing cleaning compositions may be used with all types. Trolley-mounted "Atumat" units are powered by petrol or diesel engines, or by electric motor, and can deliver up to 20 gallons per minute at 1,200 lb per sq. in maximum pressure; the model 120/60 illustrated, mounted on a Ford Thames Trader vehicle, also provides working pressures of up to 1,200 lb per sq. in and has an 850 gallon water tank and hose reels, one of which is power driven to facilitate sewer cleaning.

The pump units are of sturdy construction and require little maintenance. All parts in contact with water are of stainless steel or gunmetal, and cylinder working surfaces are hard chromium plated. The pistons are of wear resistant plastic, adjustable externally and easily interchangeable. The gear-box mechanism is enclosed in an oil bath which is double-sealed against leakage, and all shafts are mounted on ball bearings. The units have an automatic pressure-regulating valve, and a glycerine-filled pressure gauge fitted with a damping device.

For surface cleaning, a two-handed jet with trigger release is supplied, to which a variety of nozzles can be fitted. *Metering Pumps Limited, 21 The Mall, Ealing, London W5.*

INSULATION TESTER

Magnetically Shielded

A NEW insulation tester has now been released: this is the Model 130C, which covers an unusually wide range of resistance readings.

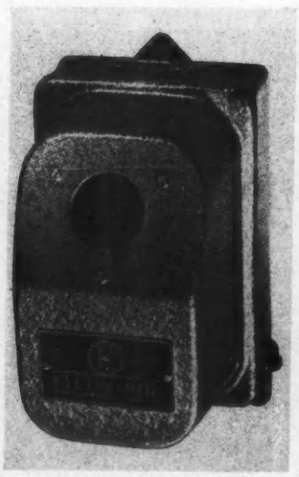
The total resistance measurements covered are from 20 ohms to 1,000 megohms. For insulation measurements a test voltage of 500V dc at infinity is applied to the component under test via a safety push-button switch.

Measurements are made on a clear, easy-to-read 5 in scale, and the meter movement is of centre-pole design. This movement is of strong construction and has sprung jewels to withstand rough handling; sensitivity is quoted at 37·5μA. An interesting feature is that the meter is magnetically shielded, which is a significant provision when the instrument is used near RF fields.

Applications are foreseen in the testing of resistors, condensers, switches, transformers, motors, elements, domestic appliances, and for continuity. The instrument is intended for operation from ac mains between 120V and 240V, 40-60 c/s; the primary of the mains transformer has fuses and the mains adjustment panel and fuse holder are readily accessible. Light and portable, the unit is enclosed in a strong and compact Bakelite moulding. *Taylor Electrical Instruments Limited, Montrose Avenue, Slough, Buckinghamshire.*

LIGHTING CONTROLLER

Automatic



THE Elcontrol PSL2 lighting controller is a small self-contained photo-electric amplifier which controls the switching on and off of electric lighting according to the decline and increase of natural daylight.

When the daylight falling on the built-in photocell decreases to the "switch-on" level, the relay in the unit is de-energized, and the lighting circuit is completed. When the daylight level rises to 1 foot-candle more than the switch-on point, the relay is energized, and the lighting circuit is switched off. If the artificial light itself affects the photocell the differential of 1 foot-candle can be increased until stable performance is reached.

This unit can be used to control any number of lights and can, in turn, be controlled by a time clock when lights are no longer required. The electronic assembly is chassis-mounted and housed in a weatherproof cast aluminium case. One control sets the falling light level to give the switch-on point and the other sets the rising light level for switching off. Dimensions are 9⅛ in by 5⅛ in by 5 in projection. *Elcontrol Limited, Wilbury Way, Hitchin, Hertfordshire.*

GENERAL DUTY DRILLS

Two-Speed

WITH a capacity of ⅜ in, two new general duty drills, types TS35 and TS35c, have been introduced to meet a demand for a larger capacity low-priced two-speed drill.

The machines are similar in appearance to the manufacturer's previous models, TS24c and TS24, these being designed also for two speeds; but the present models have completely new motors which are claimed to develop at least 30 per cent more power.

The design gives useful balance features, and the speed changeover is made quickly by the movement of a plunger. The TS35c is fitted with a ⅜ in keyed chuck and the TS35 with a No. 2 morse taper sleeve. The versatility of the machine, with a high speed of 1,350 rpm for ⅛ in drilling and 550 rpm for ⅜ in drilling makes it suitable for both metal and wood operations.

Benefits to the user are expected to include the availability of correct speeds for efficient drilling up to ⅜ in capacity, together with the need to carry only one machine instead of two, as well as the initial economy of one machine serving instead of two. A wide range of dc and ac voltages is available; distance from centre of spindle to outer casing is 1 $\frac{5}{16}$ in and gross weight is 13¼ lb for the TS35c model and 13½ lb for the TS35 model. The overall lengths of the drills are 15⅜ in and 17⅜ in respectively. 32 and 50 V special models are available. *Wolf Electric Tools Limited, Pioneer Works, Hanger Lane, London W5.*

ELECTRIC JIG GRINDER

High Torque

THE "Precise" electric jig grinder is also suitable for carbide jig milling, and functions at speeds and feed rates not available with low torque air turbines.

Comprising a high torque Precise electric quill in a compact steel housing, the machine is able to finish holes in hardened steel from 0·040 in to 3¼ in diameter to tolerances well within 0·0001 in with surface finishes under 10 micro-inches. Three models are available, complete with infinitely variable electric speed control operating from 240V supply, to give continuous speed regulation to the jig grinder between 15,000 and 45,000 rpm with a power output of ¼ hp.

Model JA has automatic feed in increments of 0·00025 in and has a dial counter; weight is 10 lb and overall length 8 $\frac{5}{16}$ in. JM has manual feed with infeed reading in 0·0001 in increments through a Vernier scale; weight is 8½ lb and overall length 7 $\frac{5}{16}$ in. Model J is without feed: its weight is 7½ lb and overall length is 5¾ in. The unit converts a vertical milling machine or can be readily mounted on to a jig borer. *Matbro Machine Tools Limited, Matbro House, Beddington Lane, Croydon, Surrey.*

WIRE STRIPPERS

Automatic

TWO new wire strippers in the H35 Series have now been added to the Hellermann range.

The standard model is particularly suitable for normal commercial use and will strip wire clean up to a length of ⅞ in. An automatic device holds the jaws open without crushing, and nicking, cutting or fraying effects are virtually eliminated. This tool is appropriate for production stripping of lighter gauge wires, automatic wiring, radio and instrument wires and cables and telephone wiring. The blades are easily cleaned; the tool weighs only 14 oz.

The De-luxe model has been designed for use on aircraft and guided weapon cables and similar precision work. A new type of blade construction together with the higher holding power of the broad jaws is said to make for fast and accurate stripping. This version also has been designed to strip without nicking or scraping wire and without marking insulation; its weight is again 14 oz. *Hellermann Limited, Crawley, Sussex.*

Army Fire Power: Tank and Anti-Tank Guns

Guided missiles and recoilless guns, used by infantry against armour, achieve penetration by means of shaped explosive charges; tank guns by high projectile velocity.

By R. M. Ogorkiewicz, M.Sc.(Eng), A.M.I.Mech.E.

THE evolution of army weapons, from small arms to anti-tank missiles, is towards increased weight and effectiveness of fire. A previous article (ENGNG., 16 June '61, p. 830) showed how the fire power of small arms had been improved by wider use of automatic loading, closer control and higher penetration. Greater accuracy and penetration have also contributed significantly in the development of tank and anti-tank weapons.

ANTI-TANK RECOILLESS GUNS

With the increasing mechanization of the ground forces and the large-scale use of tanks and other armoured vehicles, the question of armour-piercing weapons becomes more important than ever. At present the standard anti-tank weapons are the 3·5 in rocket launcher used for close-in defence and the 120 mm Mobat recoilless gun used at infantry battalion level. The former is of American origin and it is all the more interesting, therefore, to note that the US Army has recently introduced two different short-range anti-tank weapons to replace it.

One is the XM72 anti-tank rocket grenade, which can be carried and fired by one man from a disposable carrying-case-cum-launcher; the other is the 90 mm M67 medium anti-tank weapon, shown in Fig. 1, a light 33 lb shoulder-fired recoilless gun for use at infantry platoon level. The M67 has greater accuracy and range than the 3·5 in rocket launcher, which has been the standard platoon anti-tank weapon since the early stages of the war in Korea, and this type of weapon is likely to be seen more widely.

Recoilless guns, in which the momentum of the projectile is balanced by the momentum of the gases of the burnt propellent charge escaping rearwards through a nozzle, were originally used by the Germans, from 1941 onwards, as light infantry guns. Since 1945, however, they have been developed chiefly as anti-tank guns and the 120 mm Mobat is but another—though currently the largest calibre—example of this category. It is of British design and can trace its ancestry, through the earlier 120 mm Bat, to a 4·7 in recoilless anti-tank gun began in 1945.

Fig. 1 American 90 mm M67 recoilless anti-tank weapon for use by infantry platoons. It has both greater accuracy and range than the standard 3·5 in rocket launcher it is designed to replace.

During the course of the development, the weight of this type of gun has been drastically reduced and the latest version, the 120 mm Wombat, seen in Fig. 2, weighs only 650 lb, compared with about 1 ton for the Bat, for instance. The reduction in weight has been achieved by the use of very high strength steels in the barrel and breech mechanism, the use of light alloys for the carriage and the elimination of the shield.

As an aid to ranging, the Wombat is fitted with an American 0·5 in M8 semi-automatic spotting rifle, which was introduced some time ago on the corresponding American weapon, the 106 mm M40 recoilless rifle, and which fires special spotter-tracer ammunition.

To increase their mobility and to enable them to change position quickly, which is essential in view of their conspicuous back-blast, recoilless guns are commonly mounted on light trucks. So far, however, few more suitable mobile carriages, in the form of light armoured vehicles, have been developed. Until recently the only two examples were the Ontos of the US Marine Corps, which mounts six 106 mm guns, and the Japanese SS with two 105 mm guns, but now the French Army has also introduced an *Engin Légèr de Combat* with a 90 mm gun and the American Army is developing a light armoured vehicle for its infantry battalion anti-tank recoilless guns.

MISSILES AND WARHEADS

An anti-tank weapon which complements recoilless guns and which may also compete with them is the anti-tank guided missile. The first was the German X-7 of 1944-45, and the concept was subsequently pioneered by the French SS-10, which is now in service with several armies. This year the British Army

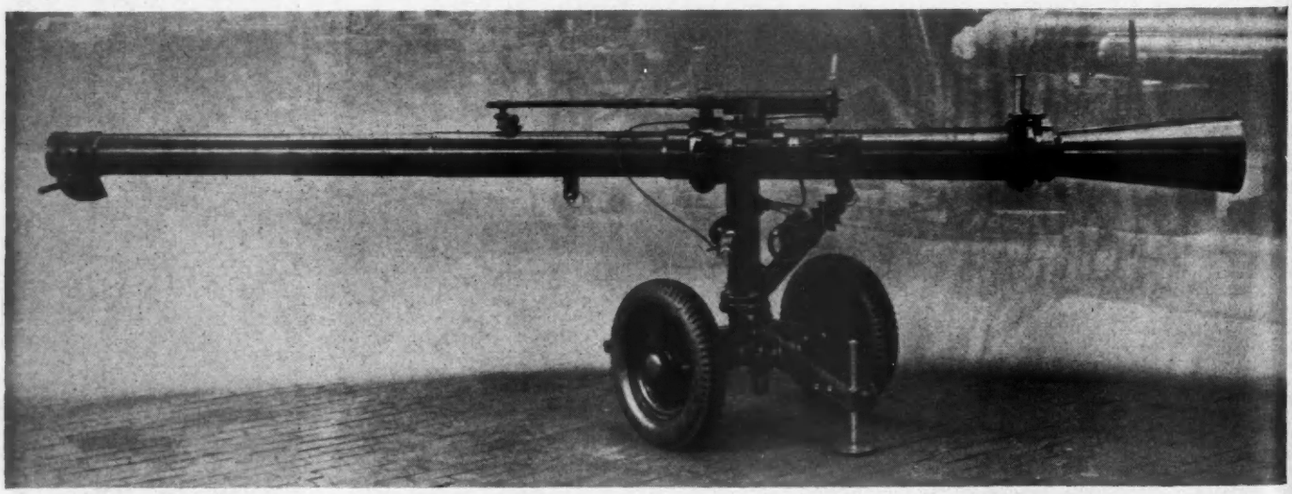


Fig. 2 The Wombat 120 mm recoilless anti-tank gun with 0·5 in spotting rifle weighs only 650 lb. To cut down the weight, very high strength steels have been used for the barrel and breech mechanism, and light alloys for the carriage.

Fig. 3 United States M60 main battle tank shown fitted with the 105 mm gun that has been designed at the British Armament Research and Development Establishment.

acquires its first operational anti-tank guided missile in the shape of the large Australian-designed Malkara, and will also carry out trials with the much smaller Vigilant, developed in a commendably short time by Vickers-Armstrongs as a private venture.

The 31 lb Vigilant, like other similar missiles, is light enough to be handled by one man and if adopted would be used by the infantry; the employment of the much heavier, 206 lb Malkara has been assigned to the Royal Armoured Corps and it will be mounted in a special armoured car. Similarly, to increase their mobility, missiles such as the French SS-10 are commonly mounted on Jeeps.

All the current anti-tank guided missiles employ visual command guidance and a trailing wire link, which under suitable conditions enables them to engage targets at ranges of 200 to 2 000 yards with a high degree of accuracy. For their armour-piercing performance they rely chiefly on shaped, or hollow, charge warheads. These warheads achieve penetration by the focused blast energy of their explosive content, or, to be more precise, because on detonation the thin copper liner of the conical cavity in the nose of the missile forms a long thin jet travelling at very high velocity, of up to 30,000 ft per sec, and the impact of this high velocity jet produces extremely high pressures which perforate the armour plate. The maximum thickness of armour which shaped charges can penetrate is up to 3 to 4 times the charge diameter and in theory, therefore, even the smaller missiles with warheads of 4 in diameter can penetrate the thickest known tank armour.

WARHEAD SIZE

But this effect does not mean that guided missiles will wipe tanks off the battlefield. In practice, penetration is apt to be less than that at optimum stand-off distance, just as the number of hits is likely to be less than under proving-ground conditions. Moreover, mere penetration of the armour plate is not enough; the damage must be lethal and this means sacrificing depth of penetration for the sake of a larger penetration diameter or using a larger warhead for the same depth of penetration. In view of this, there is likely to be a trend towards, or at least more emphasis on, missiles with larger-diameter warheads.

Another type of anti-tank warhead is the squash head, a type pioneered and so far chiefly advocated in this country. It relies for its anti-tank performance on detonation in close contact with the armour plate. The soft explosive head of such a HESH missile or projectile does not penetrate the armour but its detonation at the surface of the plate causes spalling or scabbing—a separation of lethal metal chips from the inside surface of the plate, the amount of this depending on the area of the plate in contact with the explosive at detonation and inversely related to the thickness of the plate.

Although the two types of warheads may be regarded as alternative and competing, the squash head is generally considered more suitable for heavy warheads and for higher velocity missiles or gun projectiles, whereas the shaped charge is thought by some more appropriate for smaller size warheads and lower velocities.

TANK GUNS

The use of shaped charges or squash heads is essential, of course, with anti-tank guided weapons or recoilless guns, whose missiles or projectiles do not have sufficient velocity to penetrate armour plate by virtue of their kinetic energy, as do high-velocity armour-piercing projectiles. High-velocity anti-tank guns with which this type of ammunition was used have now largely gone out of use but high-velocity guns still constitute the main armament of tanks, and tanks are regarded as the most effective means of defeating other tanks.

In consequence, there has been considerable further development of high-velocity tank guns and of special tungsten-cored armour piercing ammunition. In this field this country has been holding the lead with tank guns firing armour-piercing discarding-sabot, or APDS, projectiles, which discard their body and base after leaving the muzzle, in contrast to the earlier type of tungsten-cored composite rigid, or APCR, shot, where the body and core travel together to the target.

The development of the APDS ammunition began with the 57 mm 6 pounder and 76·2 mm 17 pounder guns of 1944-45, and its performance has been greatly increased with the 83·9 mm 20 pounder and other more recent tank guns. The muzzle velocity of the APDS projectiles is now of the order of 4,800 ft per sec, which is not only well above the 2,900 ft per sec or so of conventional armour-piercing (APCBC) ammunition but also the 3,300 to 3,900 ft per sec typical of the APCR ammunition used in German, Russian and American tank guns.

There is no better evidence of the success achieved by the Armament Research and Development Establishment than the unprecedented adoption of the British 105 mm tank gun for the new American M60 main battle tank, as seen in Fig. 3. This gun is to be used also in the new German tank and is shown mounted in the latest version of the Centurion in Fig. 4.

GUN CALIBRE

By comparison with the original model of the Centurion, which, 16 years ago, was armed with the 76·2 mm 17 pounder, the 105 mm gun Mark 10 demonstrates the progressive increase which has taken place in tank gun calibres.

Bearing in mind the calibre of current tank guns, it is somewhat surprising that the new self-propelled gun which is being developed will be only of 105 mm calibre. Like the 7·62 mm rifle cartridge, this calibre was adopted for the sake of the standardization of ammunition within NATO, and it represents at least an advance on the hitherto standard 87·6 mm 25 pounder field gun.

Somewhat similar comments apply to the new 81 mm mortar, which is to replace the earlier 3 in type, and in calibre bring the British Army in line with the rest of NATO. Its performance, to which a lot of study has been devoted, is said to be superior to that of other weapons of this calibre but judging by the attitude of other armies there is still a need for a larger mortar, of about 120 mm. Thus, in this as in other fields, there is a need for further developments and if there is reason for satisfaction with some of the results attained in recent years there is none for complacancy, both on account of developments elsewhere and the recent difficulties in selling British arms abroad.

Fig. 4 The British 105 mm tank gun, shown here fitted to the latest version of the Centurion, has been adopted by both the United States and German armies.

Flux Distribution

IMPORTANT discoveries or sensations cannot be found in the seventh annual report of the United Kingdom Atomic Energy Authority which has just been published. It has been a year of steady progress Sir Roger Makins, Chairman of the Authority, stated, while research has continued and engineering problems have been solved and the first Calder Hall reactor has completed five years of successful operation. Revenue from Calder Hall and Chapel Cross for the production of electricity amounted to approximately £5 million last year.

Calder Hall and Chapel Cross

The eight reactors gave almost trouble free operation throughout the year. Increased efficiency has been sought by raising the level of heat output and reducing the off-load time required for refuelling and scheduled maintenance: the former has been achieved by raising the fuel element temperature and having a more even heat distribution in the core, and the latter by reducing the off-load period from 11 weeks for the charge of the Calder Hall No. 1 reactor to the present period of about four weeks. Fig. 1 shows the income in annual electrical production. The gross heat output is now about 20 per cent higher than the design figure; modifications have been made during the past year to some turbo-alternators to enable the excess steam to be utilized and the generation of electricity increased—further modifications will be made during the next eighteen months. The average irradiation level of the fuel elements is over 1,000 MWd per tonne. Some channels in the centre of the core have reached an exposure of 1,500 MWd per tonne and a number of elements have been irradiated to over 2,000 MWd per tonne, with only a 2·3 per cent failure. Certain long irradiation experiments have reached levels up to 3,000 MWd per tonne, which is the average level assumed for the civil power stations.

Advanced Gas Cooled Reactor

Testing and commissioning of all the AGR equipment before fuel loading will begin in August and criticality is planned by the end of the year. The problems associated with the use

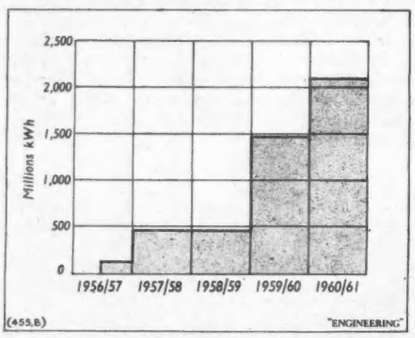


Fig. 1 Total annual net generation of electricity at Calder Hall and Chapelcross.

of uranium dioxide in the form of clusters of thin rods have kept the BICEP team busy throughout the year to determine the uranium 235 enrichment required to keep the reactor critical for the projected life of the fuel elements, and to estimate the heat distribution. A few beryllium cans are to be placed in the first core loading in places of lower temperature, otherwise the canning will be of stainless steel throughout. Beryllium cannot be used within 50° C of the temperature planned for the reactor.

Dounreay Fast Reactor Experiment

The maximum power level reached to date is 1·5 MW when nitrogen entrainment made it necessary to incorporate certain modifications. The cover gas nitrogen was found to become trapped in the sodium coolant, thus altering the coolant density. Modifications have been made at three places where the entrainment occurred: in the expansion tank when the sodium level dropped too low, in the thermocouple tubes and in the annulus between the control rods and the sheaths. The modifications will be complete by the end of the month and it is hoped to be able to increase the power level to 15-20 MW by the end of the year. Physical and kinetic experiments will be made in time for a possible change in the core in the spring of next year. The prediction of the critical loading of the reactor was correct to within one fuel element and the reactivity controlled by the control rods was accurately predicted.

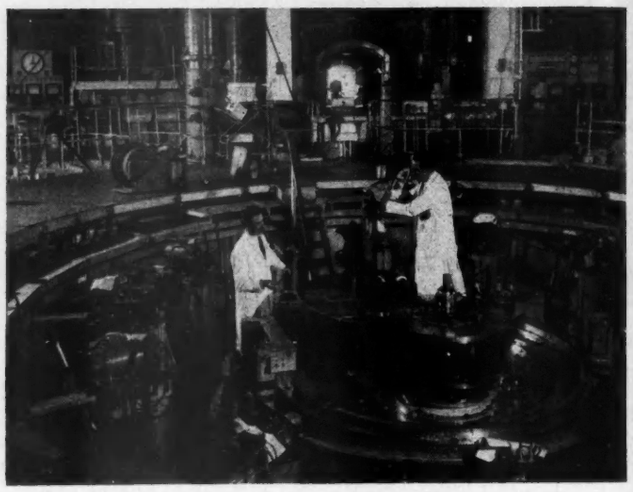


Fig. 2 An introscope mounted on a valve over one of the charging holes through the inner rotating shield of the Dounreay Fast Reactor during the recent modifications.

High Temperature Gas Cooled Reactor

The civil engineering work on the Dragon project has risen well above ground level. It has already been realized that the five year agreement for the life of the project is not going to be sufficient to execute all the work that is required by March, 1964. Consultations are now progressing with the Authority to extend this period. The Authority is the main contributor to the Dragon budget, providing about 60 per cent of the finance. Experiments with a second core loading have covered a range of core and reflector temperatures up to 630° C, including measurements of temperature coefficients of reactivity, of power distribution in the core and conversion factor. To remove the fission products from the helium coolant a combination of low temperature condensation (— 196° C) and adsorption equipment has been recommended and design information has been provided. The high operating pressures and temperatures of the coolant have brought new problems, but the gas blowers are using gas bearings and gas seals which will overcome the lubrication problems. Although the Dragon reactor is to use uranium 235 and thorium initially, investigations are being made into the plutonium-thorium-uranium 235 cycle.

Other Reactor Systems

Considerable information has been obtained by the Authority on the Steam Generating Heavy Water Reactor, and a series of reactor physics experiments performed on DIMPLE and LIDO have investigated problems using fuel elements consisting of clusters of thin uranium dioxide rods in the presence of two moderating materials—light water coolant and heavy water moderator. A series of sub-critical experiments have been planned to obtain more information on the reactor physics, with particular reference to thermal flux peaking. Variation of neutron spectrum across a lattice cell will be measured to establish the peaking. A major mechanical problem is the jointing of the zirconium pressure tubes carrying the coolant through the core to the stainless steel header, since the two materials have different coefficients of thermal expansion. There is a joint programme with Canada and Sir William Cook said that the Authority is expected to make a decision by the end of the year whether to build a reactor of this type.

Research of Fluidised Beds

Fluidisation is a technique used by the Authority in manufacturing uranium from ore concentrates, when a liquid or a gas flows through a bed of particles. There is a threshold fluid flow above which the bed lifts and is supported by the fluid, and at higher fluid flows the bed behaves as a fluid. Good contact is maintained between the solid particles and the fluid, and very good heat transfer conditions prevail. Investigations at Harwell aim at establishing a basic theory for the fluidised bed concept and the problem of gas distribution and bubble action is being studied. It has also been established that counter-current conditions can be obtained by the use of a tapered bed.

Research into Ceramic Fuels

" Reaction Sintering " of uranium and carbon powders is a new technique that has been developed at Harwell for the preparation of uranium carbide with low open pore space; it is based on the retention of liquid uranium for a closely controlled and limited time. The method is of potential interest since it would replace expensive arc-melting and casting methods. Successful preparations of homogeneous and stoichiometric uranium-plutonium dioxide solid solutions of low porosity from the mixed powders have been made. Considerable work is being done to gain a deeper appreciation of polycrystalline ceramic materials and studies are being made of single crystals.

Isotope Front

A four per cent improvement in the efficiency of the diffusion plant at Capenhurst was made last year. In addition to highly enriched material being taken from one end of the plant, uranium hexafluoride was drawn from the cascade at low enrichment for certain projects. Since the abandoning of the centrifuge method of separation due to the success of the diffusion approach, major advances have been made in vacuum engineering, the handling of uranium hexafluoride and the design of gas bearings; the Authority has started a small development programme to review the centrifuge method.

At Wantage the radiation source has recently been increased from 130,000 curies of cobalt 60 to 270,000 curies. The shielding will accommodate 500,000 curies allowing for further expansion The sale of radioisotopes rose by 10 per cent last year to £1,300,000.

Companies

4,200 Hours Unbroken Computer Operation

ELLIOTT-AUTOMATION have heard from Louisiana that their 803 computer installed there as the data processing unit of the Panellit 609 Information and Computing System in a Gulf States Utilities power station, has completed 4,200 hours of continuous operation without a single failure. Both Elliott Brothers (London) Limited, who made the computer, and PANELLIT Limited, who designed and supplied the Panellit 609 system, are members of the Elliott-Automation group.

This record run of 4,200 hours of non-stop operation is probably the longest continuous operation of a computer ever recorded. It demonstrates both the very high standards of reliability demanded by applications of this kind and successful result of the work Elliott's have put into establishing a standard of reliability in computers which is second to none in the world.

A similar Panellit 609 system, exhibited at the British Trade Fair in Moscow, has been bought by the Committee for Complex Automation in the Chemical Industry for installation in a major chemical plant in the Soviet Union.

There are two Panellit 609 systems in operation in the United Kingdom. One is at the Nuclear Power Station at Calder Hall and the other, in the Stocksbridge works of SAMUEL FOX AND COMPANY controlling the steel billet cut-up line there, is the first application of a computer for the on-line control of an industrial process in the United Kingdom. Seven other Panellit 609 systems are in operation in the United States and a number are on order for continental countries.

Pouring More Money into Manufacturing

Development of its branch organization and more effective publicity in making its facilities known are given by Lord Piercy, chairman of the INDUSTRIAL AND COMMERCIAL FINANCE CORPORATION, as two principal reasons for the record level of business transacted during the year.

The volume of ICFC's annual financing had risen as high as £7 million as long ago as 1950/51 and Lord Piercy in his annual report was not inclined to see the higher level of industrial capital investment or the continuing competition for financial assistance and support as the reasons for the trend.

In the previous year the total new business had been £6·4 million, taking the portfolio of loans and share participations to £38·4 million. Last year £9·5 million of new business lifted the portfolio to £42·1 million. On this record level of activity the profit rose from £2·82 million to £3·41 million. After interest payments and taxation this improvement had been whittled down to an advance from £1·06 million to £1·14 million.

The position of the Corporation as a lender was substantially improved by the control over funds arising from the £10 million Debenture Issue made two years ago. This rearrangement was essentially one by which the Corporation could draw the resources needed for its growth from the capital market. The position until the change had been that ICFC relied for new capital entirely on credits from its banking shareholders.

Under this policy the Corporation has issued two Debentures, borrowing £16 million. A third of this, £5½ million, has been applied to the reduction of outstanding bank loans to a more convenient level. Lord Piercy expects to make another visit to the capital market, but there is evidently plenty of time for ICFC to select and apply the best approach for its purpose.

Recalling the Radcliffe Committee's point that while the facilities for financing the smaller public company and those without easy access to the money market seem to be reasonably adequate they are not well enough known, Lord Piercy suggested that this situation is improving. ICFC's contribution is through the widening of its branch system.

It is, for instance, appearing now at trade exhibitions where the people most likely to need their services are likely to be gathered.

A Confident Prediction from Sheffield Twist Drill

One company that knows for sure what its prospects would be if the United Kingdom were to enter the European Common Market is the SHEFFIELD TWIST DRILL AND STEEL Company Limited. Reporting a 47 per cent increase in their exports last year over 1959, the Sheffield Twist Drill chairman observes that if Britain does become a member then "Your board look forward confidently to big increases in sales."

Profit margins falling below what they had been took some of the gloss off the highest turnover yet reached by the company. Net profit for the group before taxation was £698,139, an increase of £181,061 over 1959's £517,078.

Furthering its sales in the Canadian market, the company have formed a Canadian subsidiary which is financing a group holding in a warehousing company. The sales of this warehousing interest, formed in conjunction with six other British manufacturers have been "satisfactory."

Almost a year ago the group bought the full share capital of JOHNSON BROTHERS (TAPS AND DIES) Limited and JOHNSON BROTHERS (GROUND THREADS) Limited. The effect of this is to enable the group to provide a full range of taps and dies, in complement to their twist drills. Plans are being made to expand the productive capacity of the two new subsidiaries.

Sales in the first five months of this year improved over the same period of last year and the prospects are of another year of prosperity for the company.

Lamp Works Equipment Moved to Northern Ireland

The largest single movement of the entire contents of a factory from Britain to Northern Ireland in recent years was completed last month. The move is part of the trend encouraged by the Board of Trade and the Northern Ireland Ministry of Commerce to transfer industries from congested areas to places where there is room for expansion.

Since May 24 all the machinery, equipment and stores of the TILLEY LAMP COMPANY's factory at Colindale Avenue, Hendon, London, have been moved to a new factory leased from the Northern Ireland Development Council at Dunmurry, near Belfast.

PLANT ENGINEERS (MECHANICAL HANDLING), of Parkway, Camden Town, London, who carried out the job, explained: "The firm and its associated companies have transported 1,400 tons of material by road and sea to the new factory. We have had about fifty men on the job and about 150 vehicle loads have been involved.

"We have not only had to adhere to a rigid timetable, which meant that nothing could be allowed to go wrong, but we undertook to install all the plant and machinery on the new site and see that it works. Some of the machinery was in full operation within a few days of arrival."

The move has been brought about in part by the improved production facilities at the new factory of 52,000 sq. ft and the favourable terms on which it is leased. Initially work will be found for 125 people, including 79 men; later the labour force will reach 305, of whom 215 will be men.

Japanese Gear Makers on Fact-Finding Tour

The five-member fact-finding team of the JAPANESE GEAR MANUFACTURERS ASSOCIATION, which has toured extensively in Europe, has now visited the United Kingdom. They are to make further visits in the United States before returning to Japan.

In Britain, the Japanese engineers

visited W. E. SYKES, of Staines, Middlesex, and the GEAR GRINDING Company, of Shirley, Warwickshire.

At the Sykes plant the engineers (*inset*) were given a demonstration of the new Sykes V10B gear generator and later saw finished components being checked for accuracy. Sykes are currently producing a number of V10B models, with other horizontal and vertical gear shaping machines for the Japanese machine tool market. The visiting engineers showed particular interest, in the small tool division, in the techniques employed in the production of Sykes precision gear shaper cutters, hobs and shaving tools.

The fact finding team was conducted round the production shops of the Gear Grinding company who have obtained some valuable export orders in Japan. SEKIYA and Company, their agents in Tokyo, showed four machines from the Orcutt range at the Tokyo International Trade Fair last April.

New Company to Produce Filters

An independent company has now been formed to develop the Fram business to the full. Hitherto Simmonds Aerocessories Limited of Treforest, Pontypridd, Glamorgan, have been the sole licensee in Britain.

The new company, FRAM FILTERS Limited, will operate from the same address and has acquired the complete engineering, research, and sales facilities from Simmonds Aerocessories, including a newly constructed modern factory of 90,000 sq. ft at Treforest. Sales and export offices will be maintained in London. All current orders have been taken over by the company and continuity of supplies of automotive and industrial filters and water separators will be maintained.

One of the major functions of the company, which has English, French and American directors, will be to provide advanced product research in all types of air, fuel, oil, and water filters, and render closer sales and engineering assistance to all Fram licensees in other countries. Products will be marketed direct from Treforest to Scandinavia, Holland, Greece, Union of South Africa, Portugal and other nations. The products of another subsidiary, the Warner Lewis Company of Tulsa, Oklahoma, makers of filters and separators for jet aircraft w.ll also add substantially to the sales of the new

The parent American company already has subsidiaries in Canada, Argentina, Australia, Brazil, France, Germany, Italy, Mexico, Spain, Venezuela, and New Zealand. Therefore with the additional coverage now provided by Fram Filters and that already given by licensees, the filters will be directly available in almost every part of the world.

Distribution of Financial Facilities of ICFC

Region	Outstanding at 31 March, 1960		Changes during year to 31 March, 1961		Outstanding at 31 March, 1961	
	Amount £'000	Percentage of the whole	+ £'000	− £'000	Amount £'000	Percentage of the whole
Northern	707·3	1·8	112·8		820·1	2·0
East and West Ridings	3,028·2	7·9	414·4		3,442·6	8·2
North Midland	2,634·2	6·9	700·0		3,334·2	7·9
Eastern	1,072·9	2·8		210·2	862·7	2·0
London	14,128·6	36·8	949·2		15,077·8	35·8
Southern	1,554·1	4·1	199·2		1,753·3	4·2
Western	317·0	0·8	299·1		546·1	1·3
Wales	778·2	2·0	65·4		843·6	2·0
Midland	6,178·2	16·1	619·0		6,797·2	16·1
North Western	4,192·3	10·9	222·2		4,414·5	10·5
Scotland	2,734·1	7·2	174·5		2,908·6	6·9
South Eastern	1,040·7	2·7	250·7		1,291·4	3·1
	38,365·8	100·0	+ 3,726·3		42,092·1	100·0

Coating Two High-Pressure Water Tunnels

A contract now quarter-complete called for the coating of nearly half a million sq. ft of steel tunnel and penstocks with coal tar/epoxy. Here are the company's experiences with mechanisation.

In 1960, E. and F. Richardson were awarded a contract by the Central Electricity Generating Board. This was for the protective coating of all the steel tunnel linings and penstocks in the Ffestiniog pumped storage scheme and the Rheidol hydroelectric scheme.

E. and F. Richardson nominated their associate firm of Coating Contractors to undertake the application work, and this was accepted. In July of this year Coating Contractors said they had completed about a quarter of the Ffestiniog contract, having used about 2,000 gallons of their parent company's coal tar/epoxy coating—about a quarter of what they expected to need. An automatic system of surface preparation is being used followed by application of high-build catalyzed coating by hot-spray techniques. In this article you can read about some of the difficulties which the company had to solve in putting these little-used techniques into effect.

At a very early juncture, the CEGB and their consultants decided that surface preparation by blast cleaning was virtually essential, and all subsequent tests were carried out on blast-cleaned panels. During these tests, panels of heavy-gauge mild steel were coated with materials submitted by manufacturers. At Ffestiniog, coated panels were immersed in a rack mounted in a diverted water course on site. Other tests were performed by CEGB at Leatherhead, and full-scale trials were carried out.

The contract was eventually placed with E. and F. Richardson for their Adcora A3 coal tar/epoxy to be applied in a two-coat application by spray to give a nominal dry film build of 0·020 in. Underneath it an Adcora EBC primer coat is applied to a thickness of about 0·0005 in.

The area involved in the contract is nearly half a million sq. ft—all to be coated underground—so Coating Contractors considered an automated system of blast cleaning. Their final set-up emerged as a 5 ton "train" in four parts: (1) a multistage transformer rated at 10 kVA with switchgear and contactors; (2) four vacuum blasting machines; (3) a blasting manipulator to obtain travel on three vacuum-blasting guns; and (4) a spraying trolley moved independently by winch carrying pressure pots and spray guns.

(Left) This is the mechanized manipulator for carrying out vacuum-blast cleaning. Note the three moving heads. Further down the tunnel is the spraying trolley. (Right) These pressure pots are carried on the spraying trolley. The smaller pressure pot contains heated solvent for gun and line flushing.

This apparently simple concept of a train proved to be only a starting point, as many other problems had to be solved. For instance, the manipulator had to be able to cope with changes in diameter from 7 ft 6 in upwards, and much of the tunnel and penstocks had a slope of about 1 in 3. Coating Contractors report that the train is being used at between 60 and 100 ft per day.

The sequence of operation for the complete process is as follows. First of all, two-tier pipe hangers are stud welded to the tunnel lining to support a 3 in steel air main conveying 525 cfm of air at 110 lb per sq. in and also to carry the electrical supply cable to the most distant point of working. Then, as necessary, a dam is erected at the starting point to prevent the ingress of seepage water to the working area, the dam being drained through a pvc hose by gravity. Next, the complete train is lowered by steel wire rope, employing a rope climbing hoist. Finally, plywood bulkheads are fitted at the upper and lower limits of workings, and inlet and exhaust ducting and manways are fitted. The inlet ducting is connected to a 25 hp 15,000 cfm paddle-bladed fan.

In the illustrations below, you can see the manipulators and the three paint pots. Before work can commence, personnel must crawl through the manipulator and they must crawl back between blasting cycles (of 25 minutes duration) to get to open air again.

Blasting is undertaken in 3 ft wide circumferential bands, the whole train being winched upwards with the climbing hoist every 9 linear feet. Coating Contractors comment that they have lost small quantities of abrasive from the vacuum-blasting heads, but this has happened when the heads have been adjusted incorrectly or where brushes have not been replaced when worn. Abrasive spilt in this way has had to be picked up with a vacuum cleaner before priming. It has been prevented from running down the penstock by the use of a sausage-shaped bolster.

The primer coat is applied within 25 minutes of the surface's being blasted. It dries in about 10 minutes and one of its most important functions is to "wet" the blast cleaned surface and prevent oxidation.

The coal tar/epoxy coating is applied manually by hot spray techniques, the material having a pot life of about 20 minutes at 150° F. Personnel for this operation work from a trolley so that no one treads on the blasted or primed surface before or during coating.

Inspection of blasting is undertaken minute by minute by the shift foreman at the controls of the blasting manipulator. The coating is inspected in lengths of about 500 linear ft: (1) for continuity—with a wet sponge holiday detector employing a roller type electrode damped with distilled water, to which wetting agents and Fluorescine have been added; (2) for thickness—by spot checks with magnetic thickness gauges and for a wider coverage with a pre-set eddy current type thickness gauge; (3) for cure—with solvent dampened filter paper discs, secured to the surface with magnets; and (4) for bond—by destructive cross hatching, the patches being made good by brush.

An inspector checks for continuity of the coating with a fail-safe wet sponge holiday detector.

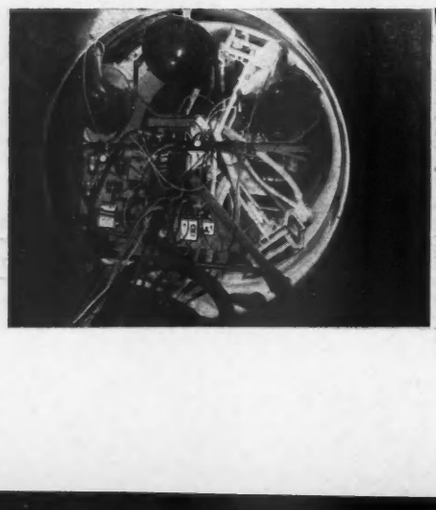
On the actual project, Coating Contractors say that very few holidays have been found, adding that this is hardly surprising in a multi-coat application in which different colours are employed for the primary and secondary coats. The bulk of their rectification work has been the removal of runs caused by spray gun failure or blockage. These have been removed with a Surform after the coating has cured, and then touched in by brush. Quite a number of areas have also been found which were below thickness and these have been rectified by brush.

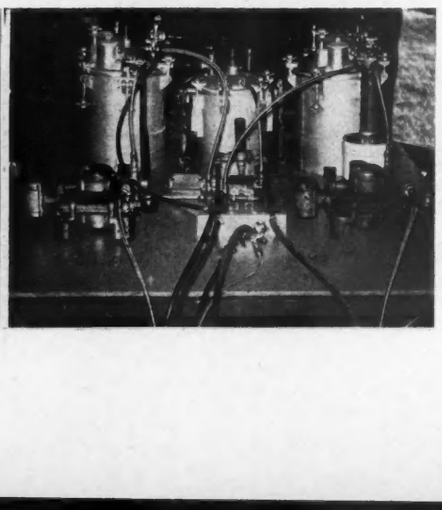
In the penstock the whole area has been squared off into approximately 2 ft squares, and within each of these five thickness checks have been made. An 8 in circumferential band has been checked for holidays every 2 linear ft of the penstock. On the results obtained, Coating Contractors say they will relax the testing schedule slightly in the tunnel. However, they add that the CEGB and their consultants are making independent random checks.

Coating Contractors say it is likely that they will have completed the first half of the contract—in other words, all the tunnels and penstocks for numbers 1 and 2 sets at Ffestiniog—by the end of September, 1961. They will then move to Rheidol until the spring of 1962. Finally, they will return to Ffestiniog to complete the second half of that part of the operation.

Inquiries from several hydroelectric authorities or their consultants are in hand, they say, but it seems unlikely that they will use the equipment exactly as originally developed. Other than items such as water separators, after-coolers and compressors which have been only partly absorbed in the contract, most of the equipment has been written off already on this project.

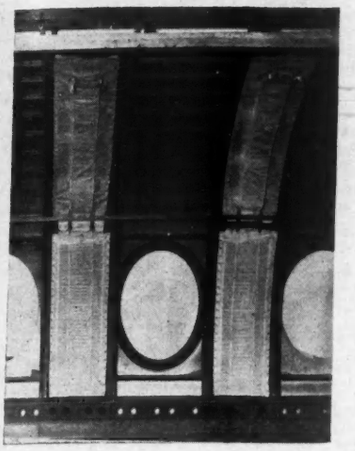
Coating Contractors Limited, Buckingham.





Pvc-Coated Terylene Duct for Aircraft

A combined heating, ventilating and sound insulation unit made from coated 1½ oz fabric is now said to be part of the standard equipment of the Vickers Vanguard aircraft. The fabric itself is made from ICI's polyester fibre and is



coated with pvc. ICI say this satisfies the requirements for high strength to weight ratio and low stretch properties as well as being non-absorbent, airtight, fire-resistant and capable of enduring temperatures from −40° to +120° C.

In the initial design of the Vanguard, Vickers-Armstrongs (Aircraft) decided to make side wall heating of the passenger cabin an integral part of the heating and ventilating system. Baxter, Woodhouse and Taylor of Poynton, assisted Vickers in development of the ducts. Their shape is kept either by stiffened insulating materials, by tensioning, or by a combination of both.

Imperial Chemical Industries Limited, Millbank, London SW1.

Asbestos Brake Linings for Cable-Layer

Ferodo woven asbestos brake linings have been fitted on the paying-out and holding-back gears aboard the GPO's new 6,200 tons cable-layer, HMTS Alert. This ship will shortly be

engaged on laying the St. Lawrence section of the CANTAT cable from Grosse Roches in Quebec to Corner Brook in Newfoundland—a distance of 402 nautical miles.

The Alert has two paying-out gears and two holding-back gears mounted forward which were supplied by the Telegraph Construction and Maintenance Company. In each case, contrary to standard practice, say Ferodo, the linings are attached to the brake drum, the braking force being applied by a mild steel brake band fitted with a copper sheath for water cooling.

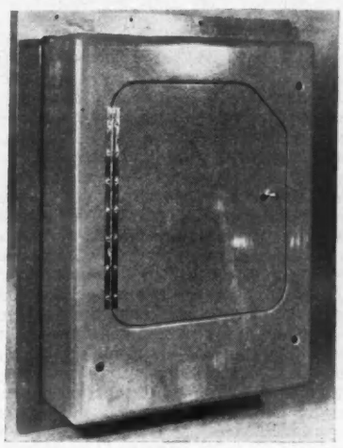
This illustration shows one of the 14 MR41 segments being attached to the 7 ton cast steel cable drum which is 7 ft 6 in diameter and 3 ft 6 in wide. Ferodo say that this method of fixing with bolts in tapped holes will simplify replacement. The brakes have been designed for an emergency holding force of 30 tons at rest and of 8 tons while paying-out during normal duty at 8 knots. Working temperatures up to 200° C are expected. For this reason, the brake band will be cooled by water flowing at 65 gallons per min. Little heat is expected to get through the 1 in thick lining to the drum.

The holding-back gear will give a continuous tension of 1 ton at maximum speeds.

Ferodo Limited, Chapel-en-le-Frith, Stockport.

Glass Reinforced Plastic for Destination Box

This destination box cover is made in glass reinforced polyester for diesel locomotives on British Railways' Southern Region. It is one of several made by Vitesta, a subsidiary of Vitafoam specializing in mouldings for the engineering trade. Indicator mechanisms are being fitted by Transport Engineering and



Equipment.

Vitesta say that the material eliminates the problem of condensation inside the box, which by corroding the white paint used as a reflection surface proved one of the major disadvantages of metal. They also consider that the ease of moulding contributes to a neater design.

Vitesta Limited, Don Mill, Middleton, Nr. Manchester.

Stainless Steel Casting Agreement

Armco patents covering a range of precipitation hardening stainless steels applicable to castings are the subject of an exclusive licence that has been granted in the UK to APV-Paramount.

Development work by APV-Paramount is said to have confirmed that the compositions evolved by Armco have properties which, when applied to steel castings, are outstanding not only in terms of high strength combined with corrosion resistance but also in reproducibility of these characteristics.

In general terms, APV-Paramount say that this range of hardenable stainless steels exhibit as castings all the advantages generally associated with austenitic stainless steels, namely, good corrosion resistance, weldability and castability, combined with mechanical and physical properties normally attributed to the straight martensitic 13Cr-steels and 18Cr-2Ni-steels.

Machining characteristics are reported as being excellent at tensile levels as high as 65 tons per sq. in. Where tensile properties at higher levels are required, say 75 tons per sq. in, machining can be completed after a preliminary heat treatment, the final properties being developed by a subsequent low temperature tempering treatment which is said to give negligible scaling and distortion effects.

APV-Paramount expect the cast steels to supersede those mentioned above especially in hydraulic engineering where corrosion resistance coupled with high fatigue strength and resistance to cavitation are important.

APV-Paramount Limited, Manor Royal, Crawley, Sussex.

Ptfe Monofilament Made in UK

In response to a request by Du Pont—the suppliers of Teflon ptfe—Richard Klinger have developed a process for making monofilament from the plastic with diameters of 0·007 in and 0·018 in.

It is far too early to really judge where filament costing in the order of £10 per 1,000 ft will find a large market, but if this comes at all it will probably include the field of filters in which some degree of stiffness is needed. At least, so think the makers. Ptfe is chemically inert and so far

as is known there are no additives in the grade of ptfe supplied to Klingers for this filament which should reduce this. Maximum useable temperature is about 300° C. The coefficient of friction is low so there may also be an outlet for the material when made up into packings. The illustration here shows some of the finer filament with one of the packings which has been knitted from it. Contrary to what they expected, Klingers say that little difficulty was caused by this slipperiness when it came to weaving. The makers say that tensile strength is about 6,000 lb per sq. in with an elongation of 250 per cent.

Richard Klinger Limited, Sidcup, Kent.

Strippable Coating for Paint Spray Booths

Pultac No. 2 is the name given to a new strippable material for the walls of paint spray booths.

The makers claim that the material can be sprayed on to any clean dry surface such as steel, aluminium, galvanized iron, vitreous enamel, glass and tiles; it is said to dry out very quickly after application and to be resistant to paint overspray almost immediately. This strippable coating will resist normal overspray thinners as well as paints and water and emulsion paints, say Pyrene.

Pyrene Company Limited, Metal Finishing Division, Great West Road, Brentford, Middlesex.

Slideway Wear Factors in Machine Tools

Considering the importance of slideway wear in machine tools and measuring machines, strangely little has been published about it. This article reviews the available information on performances of various metallic slideways.

By R. C. Brewer, B.Sc., A.M.I.E.E., A.M.I.Mech.E.
Imperial College of Science and Technology

THE principal types of surface preparation used for slideways are periphery or surface grinding, cup grinding and scraping—the latter being either draw-scraping or the more common push-scraping. It is important to be able to assess the wear characteristics of each type of surface, when sliding against both similarly and differently prepared surfaces.

Though their surface roughnesses may be of the same order, the surfaces themselves exhibit quite different characteristics. A pen record of each type of surface is shown in Fig. 1 and the differences, with regard to bearing capacity, are indicated more quantitatively by the Abbot bearing area curves in Fig. 2.

A bearing area curve is, in effect, drawn on a vertical rather than a horizontal base and the length of a horizontal line such as A B (Fig. 2a) represents the sum of the lengths l_1, l_2, etc., at a depth below the highest point on the pen-record (Fig. 1a). The greater the ratio of the area under the Abbot curve to that of the circumscribing rectangle, the better the bearing capacity of the surface, though the relationship is not necessarily linear. The value of the ratio, often called the fullness ratio, is indicated on each Abbot curve and it will be noted that the push-scraped surface has a much higher fullness ratio than the ground surfaces. It is understood that the Société Genevoise is the only company using draw-scraping, but a profile record and Abbot curve have been included in Figs. 1 and 2 as a matter of interest. In the remainder of this article " scraped " means " push-scraped."

Effect of Surface Preparation on Wear

General experience has shown that, if both surfaces of a sliding pair are cup-ground, the wear characteristics tend to be very poor so that experimental programmes have usually been conducted with one or more of the five remaining combinations. For conciseness, these will be abbreviated as follows:—

scraped-scraped	S/S
periphery ground/scraped	P/S
cup ground/scraped	C/S
periphery ground/periphery ground..	P/P
cup ground/periphery ground ..	C/P

The block diagram in Fig. 3 summarises some results of Nelsson[5] at the KTH, Stockholm. The upper part of each block shows the wear in the shorter moving specimen of material 2 (see the Table) and the lower part, the wear in the longer stationary specimen of material 3. The wear is given as the mean thickness of metal removed after a sliding distance of 65,600 ft (24,000 strokes of the test machine).

It is clear from Fig. 3 that the cup-ground surfaces have suffered the greatest wear although, in each case, they appear to have spared the material against which they were sliding. The specimens which wore least were those with scraped surfaces although the combined wear of the S/S pair was about the same as that for the C/S pair. It is thus seen that the order of increasing wear is the same as the order of decreasing fullness ratio.

However, the nature of the scraped surface is such as to provide natural reservoirs for the lubricant and in case this should have been the dominant function in reducing the wear of scraped surfaces. Nelsson[5] conducted some non-lubricated tests with scraped surfaces. The S/S combination exhibited much the same degree of wear as in the lubricated tests but the P/S pair seized at a relatively early stage in the test. It would thus appear that the bearing capacity of the scraped surface is more important than its ability to retain the lubricant although, clearly, the ground surface requires lubrication.

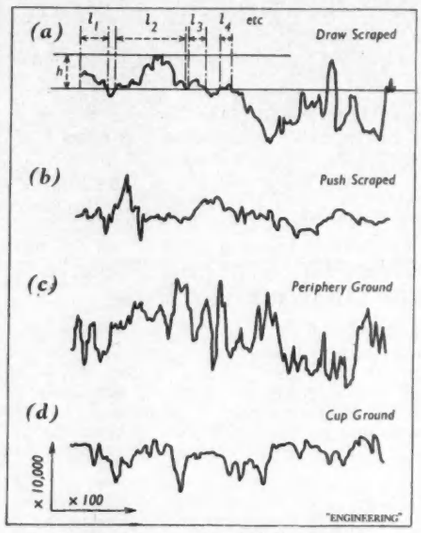


Fig. 1 Profile records of slideway surfaces.

These results are, however, for a definite sliding distance of 65,600 ft and it is pertinent to wonder whether this picture is the same throughout. Although Optiz[1] has given several curves for chilled and unchilled irons of various compositions, Nelsson[5] gives the only results from which any comparison may be made. These are reproduced in Fig. 4, from which it will be seen that the differences in wear are most pronounced in the early stages and that the curves tend to converge as the sliding distance increases, i.e. as surfaces wear more, the less does the method of surface preparation matter. By plotting the ratios of wear in a S/S pair to that in various other pairs, more linear curves are obtained and Nelsson[5] has been able to estimate, by extrapolation, that the wear curves would probably coincide after a sliding distance of about 250,000 ft.

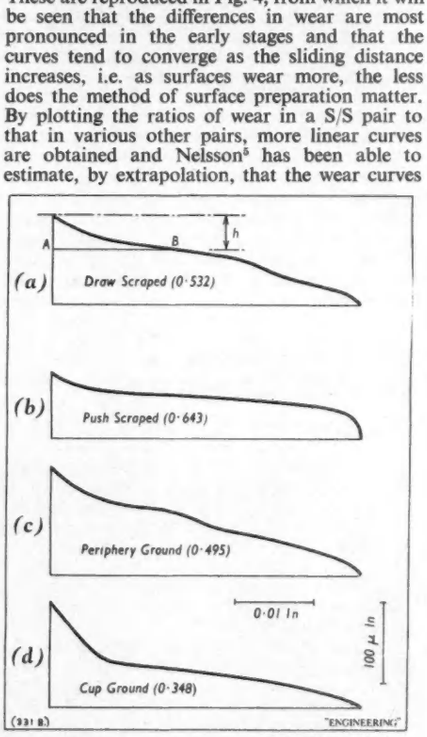


Fig. 2 Abbot curves for the records of Fig. 1. The numbers in brackets are the fullness ratios.

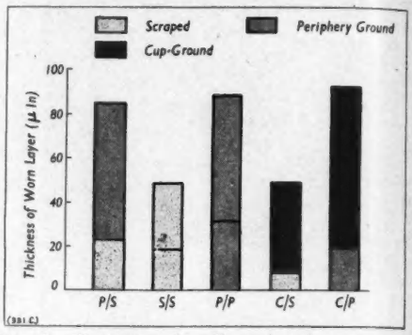


Fig. 3 Illustrating the effect of surface preparation on wear.

The results obtained from pen records of the surfaces are in agreement with this finding. That is, a periphery-ground specimen had a fullness factor of 0·612 before testing, but this fullness factor increased with time giving values of 0·87 and 0·895 after sliding distances of 65,600 ft and 164,000 ft. After a further 33,000 ft, the fullness ratio decreased to 0·854 and it would seem possible, on this limited evidence, that the fullness ratio increases to a maximum value as " wearing-in " proceeds but later decreases.

One very interesting point which Opitz[1] made was that when both mating surfaces were ground surfaces, the same grinding procedure should not be used for both. Mention has already been made of the known deficiencies of C/C pairs but neither Fig. 3 nor Fig. 4 shows much difference between a pair in which each specimen was surface-ground and one in which one surface was periphery-ground and the other cup-ground.

It has been known for some years that grinding could give rise to tensile residual stresses at the surface (Letner[6]) and it is probably of some significance that any residual stresses in a scraped surface are compressive. Unfortunately, no attempt seems to have been made to study this in experiments on slideway wear.

The Influence of Hardness

Hardening of one or both elements of a sliding pair has often been practised on the assumption that it increases wear resistance. The process of wear in machine tools is not, however, a simple one and not only can it not be assumed that hardening increases wear resistance but, in fact, it has been frequently observed that the harder material wears more. This was noted by Opitz[1] in his early investigations; in these, chilled and unchilled specimens of identical composition were used and it was found that the

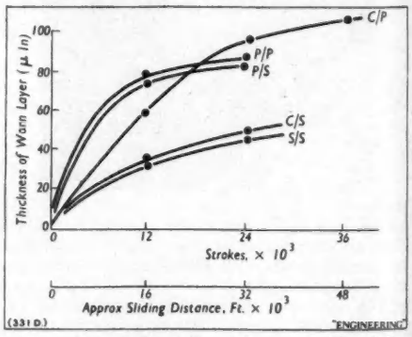


Fig. 4 The development of wear with sliding distance.

combined wear of two chilled surfaces was greater than that for two unchilled surfaces.

The investigations of Angus[4] were more qualitative with regard to wear since they consisted of a survey of the slides of about 30 machine tools which were still being used in industry, the severity of wear being classified into four grades, namely, good, fair, poor and very bad. Hardnesses were measured and Angus reports that, although the highest and lowest average hardnesses were found in the groups exhibiting the least and most wear respectively, the ranges of hardness in the four groups overlapped considerably, thus confirming that hardness is not the only, or necessarily the most important, factor in determining wear resistance. Probably the only definite point which can be made is that surfaces with hardnesses below 160 Brinell will not wear well under conditions of boundary lubrication because of the large amounts of free ferrite that such surfaces will almost certainly contain.

Nelsson's tests[5] also confirmed that hardness is not, in itself, a criterion for wear resistance but this does not mean that there is no foundation for the practice of hardening slideways. The investigations which have been cited here were almost entirely carried out under controlled conditions in which steps were taken to prevent the ingress of dust, small metallic particles, etc. Under practical conditions where this ingress cannot be prevented, there is possibly an advantage in hardening one or both of the surfaces. Lapidus and Reshetov[3] appear to have been the only investigators to have given attention to this point and they have, in fact, not only found it to be advantageous to harden one or both of the sliding surfaces but confirmed that it is still the harder surface which wears more

Opitz[1] has suggested that (*a*) it is desirable for the sliding surfaces to be of different hardness, with a hardness ratio in the range 1·1 to 1·2 and (*b*) it does not matter which surface is the harder. One curve in the paper by Opitz and Escher[2] confirms the second point but the quantitative part of the first suggestion (that the hardness ratio lie in the range 1·1 to 1·2) seems quite arbitrary. If such a small departure from equal hardness is desirable, Opitz's second point is substantiated by Nelsson[5] but, over a much larger range of hardness ratio—up to 2 or 3—Nelsson found it advantageous for the shorter specimen to be the harder. A typical result shows that, as the ratio of the hardness of shorter specimen/hardness of longer specimen increases from 0·9 to 2·8, the total wear is reduced by some 35 to 40 per cent.

A comparison of the effects of hardening and/or material composition may be made from the block diagrams in Fig. 5. The blocks marked A and B refer to combinations of materials 2-2 and 1-2 respectively (for material numbers, composition, etc., see the Table). Both blocks marked E refer to a combination of materials 2 and 3, but, in one case, both specimens were periphery ground while, in the other case, one specimen was scraped and the other periphery ground. The block marked F pertains to a combination of material 4 and a Mn-Ni-Cr steel, case-hardened to 477 BHN, and it is evident that the steel has poor wearing properties despite its great hardness. This emphasizes the dangers of extending conclusions based on hardness ratios with cast iron to other possible slideway materials. All block diagrams again show that it is the harder surface which wears more.

It is relevant, at this stage, to ask whether the effect of hardening is invariable with, or dependent on the sliding distance. Unfortunately, little work appears to have been done on this topic by any of the investigators but some results are given by Nelsson[5] and they indicate that hardening becomes increasingly ineffective with increased sliding distance (from one set of results, it can be said, without extrapolation, that the wear of hardened and unhardened pairs is identical after 50,000 strokes, i.e. a sliding distance of say 140,000 ft).

One of Nelsson's[5] conclusions which is most interesting is that the combination of two

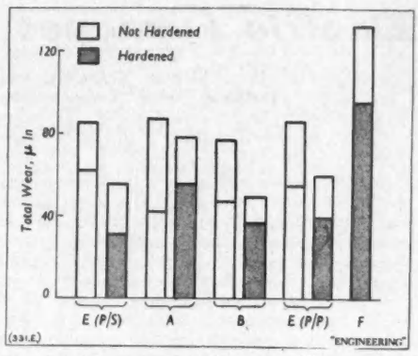


Fig. 5 Comparison of the wear of hardened and unhardened surfaces.

scraped surfaces, even when unhardened, gives almost as good a wear resistance as any other combination of hardened surfaces. The reason for the harder surface wearing more severely has not been clarified completely by any of the investigators but it seems attributable to one or both of two alternative mechanisms, (*a*) that small abrasive particles become embedded in the softer surface which then acts as a lap or (*b*) that metallurgical differences between the hardened and unhardened specimens may favour the unhardened surface with regard to scoring resistance and that this is aggravated by residual, tensile stresses in the surfaces of the specimens which have been deliberately hardened. In particular, Angus[4] has warned of the danger of producing a zone of iron carrying undercooled graphite and ferrite, when chills are used to give a dense, close-grained surface.

The Effects of Microstructure

Both Opitz[1] and Nelsson[5] conducted their tests with irons of several quite different compositions, but Angus[4] is the only investigator who gives any idea of the types of cast iron to be found in practice. His survey showed that most materials were in one of the following categories:—

(1) Medium to coarse random graphite, a little ferrite being associated with the graphite flakes (phosphorus content, normally 0·8-1·2 per cent);

(2) Coarse to medium graphite with a considerable quantity of free ferrite;

(3) Medium flake graphite—full pearlitic matrix (phosphorus content quite variable);

(4) Rosette undercooled graphite with random graphite, free ferrite and pearlite;

(5) Fully undercooled graphite with ferrite and pearlite.

In general, experience would indicate that undercooled graphite is the worst structure from a viewpoint of wear and scoring resistance, particularly under boundary lubrication conditions. Undercooled graphite is often formed, in or under the surface, when chills and denseners are used and the main protection against this seems to be the provision of adequate machining allowances.

Opitz[1] used a statistical parameter in an attempt to evaluate the effect of graphite—he laid over the unetched cast iron surface a transparent screen ruled with a square grid and counted the number of intersections between graphite veins and the lines of the grid. This number was divided by the total length of the squared network to give what Opitz called the "linear graphite distribution" (in this, allowance was made for optical magnification so that counts made at differing magnifications could be compared). Opitz's[1] results for a S/S combination were a little erratic and, although his curve showing a minimum is not without foundation (see Fig. 6a), it should be noted that the extreme right-hand point is the sole authority for the existence of a turning point. Certainly, more evidence than this is needed before either an optimum magnitude for the linear graphite distribution or the amount of wear at which it will take place can be assumed.

Nelsson[5] tried a slightly different approach

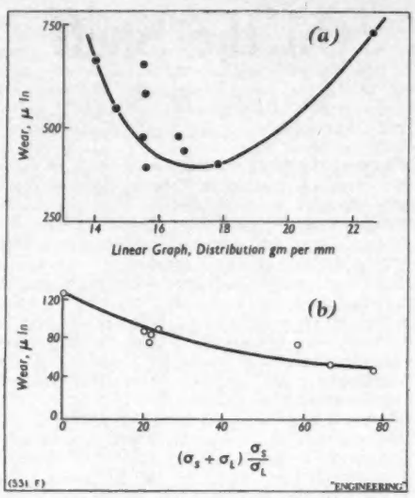


Fig. 6 Wear as a function of graphite distribution (a) after Opitz, (b) after Nelsson.

and differentiated the linear graphite distributions (σ_S, σ_L in the short and long specimens respectively) and plotted the total wear against the parameter $(\sigma_S \times \sigma_L)\,\sigma_S/\sigma_L$. One of Nelsson's sets of results is shown in Fig. 6b, from which it will be seen that a rather better correlation exists with no suggestion of a minimum.

Conclusions

(1) For slow gradual wear, the combinations S/S and C/S are best but, since the cup-ground surface contributes most to the total wear, this preparation should be used for the surface which is the more easily replaced or adjusted.

(2) As a method of attaining a reasonably low wear-rate without the high cost of scraping both surfaces, one of the other surface combinations could be employed after a period of artificial wearing-in had been allowed.

(3) There is no correlation between hardness and wear resistance but there are other factors in favour of hardening slide-ways.

(4) Information regarding chemical composition is scanty and, to some extent, contradictory; it is, however, generally agreed that the carbon content should be about 3·2-3·3 per cent.

The author would like to thank his assistant, Miss Janet Piggott, who prepared the specimens and derived the curves for Figs. 1 and 2, and also Mr. L. E. Nelsson of the K.T.H., Stockholm, for permission to reproduce Figs. 3, 4, 5 and 6b.

TABLE:—*Details of the Cast Irons Used by Nelsson*

Composition and hardness	Material No. 1	2	3	4
Per cent C	2·93	3·11	3·17	3·4
Per cent Si	1·44	1·66	2·24	2·0
Per cent Mn ..	0·87	0·73	0·56	0·80
Per cent P	0·09	0·115	0·225	0·15
Per cent S	0·14	0·13	0·136	0·12
BHN (unhardened)	221	200/212	200	187/197
BHN (hardened) ..	495	480	—	—

REFERENCES

[1] Opitz, H. "Untersuchung über das Verschleissverhalten von Gusseisener Gleitflächen." *Werkstattstechnik und Werksleiter*, vol. 34 (1940), p. 3, and p. 42.

[2] Opitz, H. and Escher, K. "Gleiteigenschaften gusseisener Gleitführungen." *Werkstattstechnik und Werksleiter*, vol. 36 (1942), pp. 11/12, and p. 213.

[3] Lapidus, A. S. and Reshetov, D. N. "Vibor materiala i konstruktsii napravlyayushchikh metodi povisheniya ikh dolgovechnosti." *Stanki i Instrument*, no. 11 (1953), p. 4, and No. 12 (1953), p. 5.

[4] Angus, H. T. "The Wear of Cast-Iron Machine Tool Slides, Shears and Guide-Ways." *External Report No. 383*, British Cast Iron Research Association; also Wear, vol. 1 (1957), p. 1, and p. 40.

[5] Nelsson, L. E. "Ytbearbetningens och härdningens inverkan pa rätstyrningarnas nötningsegenskaper." Mekan Resultat Ve 600815, Sveriges Mekanforbund, Stockholm.

[6] H. R. Letner. "Influence of Grinding Fluids upon Residual Stresses in Hardened Steel." *Trans-Am. Soc. Mech. Engrs.*, *79*, (1957), 149.

On the Shelf

By Frank H. Smith

ONE of the more amusing arguments in aeronautical history (and heaven knows there are enough) is that about Moshaisky, the Russian reputed to have flown before the Wright Brothers (the acknowledged firsts). Moshaisky's claim was " sponsored " during the Stalin regime and disclaimed when there was an anti-Stalin wave shortly after his death. Now a Dutchman named Henri Hegener, writing in *Air BP*, has given what must be the most complete and best illustrated account of the Moshaisky claim, and part of his evidence is a reproduction from ENGINEERING of 6 May, 1881, of some drawings of the engines built by Ahrbecker of London for Moshaisky's aeroplane. ENGINEERING was, of course (why " of course " I wonder?) very much on the ball with these early aviation ventures; it might be worth somebody's while to collect all that material together in a book. Hegener, in his article, says " The fact that Moshaisky's smaller engine, destined, as it was stated, ' for aeronautical purposes', was considered worthy of description in ENGINEERING (as already stated) is a convincing proof of the seriousness and scientific character of his work." So you see, even in those days. . . .

The Institution of Engineers (India) have joined the Confusion worse Confounded band. Their journal has hitherto been in two parts. From June 1961 it will be in seven parts. Three will be six times a year and four will be three times a year. If you have not had their circular about it, write to them at 8 Gokhale Road, Calcutta 20. I see they are a Royal Charter body. I wonder if they have to get anybody's permission to go fiddling about with the binding programme like this?

Heaven help the atomic people. From Documents Services, Publications Sales Unit, International Atomic Energy Agency, Kaerntnerring 11, Vienna 1, I have had six " advance information sheets " advertising different publications. From Cooper-Trent Blueprint and Microfilm Corporation of 2701 Wilson Boulevard, Arlington, Virginia, I have had the " Current price schedule of the unclassified US Atomic Energy Commission engineering drawings and related specifications as of 1 February, 1961, available in whiteprints-blueprints, duplicate tracings and microfilm." From the latter I take Cape No. 37, for instance, Ball Swivel Manipulator Tongs, 125 square footage, 60 negs. There are 739 of these Capes and you see page 1 to find out how much it is per Cape. Who's barmy? Them or me? But if Oxford is interested, " a Cape is a complete set of drawings or specifications for a given piece of equipment as listed in the USAEC's " Engineering Materials List, TID-4100 (1st Rev. and Supplements)." But *why* Cape?

As you know, John Wiley now have a place in London (except, I believe, on 4 July when they celebrate something or other with Turkey and Cranberry sauce) and from Gordon House, Greencoat Place, London SW1, you should be able to get a thumping 257 page catalogue. They've absorbed Britishness with a vengeance, as will be seen by the catalogue's endpapers and the historical note on them.

The American Society for Testing Materials go to town on their publicity. They have just elected their national officers for '61-'62 and send out over a page biography of each. ASTM Director Albert G. H. Dietz has my money. He's a member of Beta Theta Pi, Phi Beta Kappa, Tau Beta Pi, Sigma Xi and Tau Kappa Alpha. Nobody can touch him on that, and the nearest is Director Gordon M. Kline, with a mere Phi Beta Kappa and Sigma Xi. It's all as simple as Alpha Beta Gamma which is as far as I can get except when I go down river when I can sometimes reach Delta.

Electric Furnaces Surveyed

Elektrothermie: die elektrische Erzeugung und technische Anwendung hoher Temperaturen. Edited by M. PIRANI. 2nd Edition. *Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf.* (61·50 *DM*)

This is the second edition of a book which was first published 30 years ago. The editor claims that this edition has been completely revised and brought up to date, but it is hardly surprising that the book does not present a very youthful appearance. It is in fact a very middle-aged sort of volume and deals with established practice in arc furnaces, induction furnaces and various other means of electrical heating. To be called middle-aged is taken by many people to be an insult rather than a statement of fact, but in a book like this it should be taken as a mark of approbation. It is a very remarkable achievement to bring out a book of this type, which can be of considerable value to engineers who require a survey of a field of engineering practice with which they are not very familiar.

The book is a symposium compiled by ten authors all of whom are practising engineers, although some of them are also academic teachers. The approach of the contributors throughout the volume is technological rather than scientific. Much of the text is descriptive and only occasionally is it reinforced with formulae or analytical discussion. There is an abundance of diagrams, photographs and tables and the book is very easy to read, it is in fact technology at its best.

The contents range from the discussion of iron-smelting and the production of non-ferrous metals to glass furnaces, dielectric heating and measurement techniques applied to electric heating. There is a very extensive and well-arranged bibliography and a useful index of names and subjects is also provided. The chief objection to the book is its appalling price.

In thinking about this price and about the fact that many British engineers will be put off from reading the book because it is written in German, one wonders why books of this type are not produced in this country. One reason no doubt is the fact that in Germany the worlds of industry and the technical university are far more closely linked than here. The German system produces lots of technological writing whereas British universities tend to produce mainly theoretical works. Such works are often useful in their own right, but they do leave a gap. With the advent of colleges of advanced technology and the increasing importance of technical colleges in general, it is to be hoped that this gap will in due course be filled.

P. HAMMOND

Education—and After

The Complete Scientist: Report of the Leverhulme Study Group to the British Association for the Advancement of Science. *Oxford University Press.* (18*s*)

Directory of Opportunities for School Leavers, 1961. *Cornmarket Press.* (8*s* 6*d*)

Despite stubborn rearguard action by traditionalists, there is now a general feeling that education in Britain is badly out of tune with the times, that we are wasting our resources in preparing young people for a world which no longer exists. Scientists, it is loudly cried, are narrow specialists knowing nothing of the humanities, and caring less; a good deal less loudly it is remarked that non-scientists pride themselves on a total ignorance of technical matters. These are, of course, extreme points of view, but there is no question at all that some very considerable revision of our educational system is long overdue, and must be speedily made if we are not to lag still further behind our powerful competitors.

But while speed is urgent, it could be fatal. To make fundamental changes in our educational system is in any event a tremendous undertaking, and once a new policy is decided upon it cannot quickly be altered if it does not achieve the results expected of it, or—no less important—if its fruits are borne when the world situation has changed, which can happen uncomfortably rapidly. Those called upon to make the revision must number prophecy among many other gifts.

As so often happens with major controversial issues, much of the argument on educational reform has been thrown to and fro with little knowledge of the facts. The Leverhulme Committee of the British Association, under the distinguished chairmanship of Sir Patrick Linstead, has performed a valuable national service in making a dispassionate report on the present education of the prospective scientist in school and university. The report complements the Crowther Report of 1959. It was brought out with commendable speed, for the first meeting of the Committee was held in November 1958 and the report was ready for printing in March 1960.

The Committee was asked to consider " the desirability of broadening the education of those intending to become professional scientists and technologists " and to consider how, if desirable, this might be done. By " broadening " is here meant simply making provision for the study of non-scientific subjects. In this context it is important to recognize that science is in itself a broad subject showing an immense variety of facets, and is educationally just as important as any other branch of learning. It is therefore good to see that the Committee duly noted that the education of scientists and engineers is in no worse case than that of their non-scientific fellows. An integration of science and the humanities, instead of an attempt to keep them in watertight compartments, is at the very heart of the problem. From the report there emerges a very clear picture of the present situation in British schools, in terms of hours given to various subjects at all ages. Qualitatively, however, the Committee found themselves on less sure ground; although rightly stressing that in teaching it is " quality that counts above all else," there is no yardstick by which quality may be measured. The position with regard to science teachers is indeed discouraging and, unhappily, it is fundamental to the whole problem. No scheme of education, no provision of fine buildings and equipment, is worth anything at all unless sufficient good teachers are also available.

The situation is already bad and unquestionably it is getting rapidly worse. For years, schools have failed to acquire the best men; as one headmaster aptly put it, " we are living on capital." In the view of the Committee the relatively few younger men who are electing to go into teaching are, on the whole, of lower calibre than the older men who are retiring. The main trouble is the economically competitive demands of industry and, more recently, of other big bidders, such as the scientific civil service. The Committee estimated that of all men who graduated in 1950, some 30 per cent went into industry, and industry got 30 per cent of those with first-class degrees. Numerically, the schools did not do so badly, or they got 23 per cent of graduates—but they got only 9 per cent of the firsts.

It is hard to see how this problem is to be resolved, but it is clearly one to which industry must give much more thought than it has done in the past. Naturally, at a time of rapid expansion such as the present, the firms want

the best men—indeed, the availability of good men is often a determining factor in industrial growth. But, equally clearly, industry will suffer if the next generation of graduates has been badly taught. If the present tendency is not checked " the country must be prepared to face a steady and inevitable impoverishment of teaching standards, and as a result, of the standard of education and professional competence of its scientists and engineers." More recently, Professor Thwaites has directed attention to an equally deplorable state of affairs in mathematics, very rightly called the handmaiden of the sciences. If we have a prolonged shortage of both scientists and mathematicians the outlook is grim indeed. This is an immensely difficult problem, but it cannot be shirked. The Committee, prudently, considers the question of teachers' salaries as outside its terms of reference —but this does not stop it saying bluntly that the country must pay the proper rate for the job.

What of the products of the present teaching system who are turned out into the hard world to make their living as best they can? For these, and those who try to advise them, the *Directory of Opportunities for School Leavers 1961* contains a good deal of information. Ironically, in view of the comments of the Leverhulme Committee, only a single page is devoted to the needs of those whose thoughts may be turning to teaching as a career.

The first part of the book consists of a number of editorial chapters, of varying merit, on such topics as " Where to get advice " and " How to apply for a job." The greater part, however, consists of statements from firms and other organizations about the kinds of jobs they can offer school leavers. But the list is very far indeed from being comprehensive. For example, it includes Littlewoods Mail Order stores, but not Woolworths or Marks and Spencers; P. and O.-Orient Lines but not Cunard; Fords but not the British Motor Corporation; Guinness but not Ind Coope; in catering, Fullers but not Lyons, although the latter's subsidiary Leo Computers Limited appears. The quality of these contributions varies considerably. Some are very good; a few make such dreary reading that their recruiting value must be nil, if they do not positively deter potential recruits. The classified index contains many entries under unexpected headings, and often seems to bear little relationship to the training index.

In the main, however, the book is to be welcomed and should prove useful to parents and careers masters and to school leavers themselves. It is to be hoped that in future editions the publishers will make good some of the omissions and so more fully justify their title.

TREVOR I. WILLIAMS

When Structures Get Hot

Theory of Thermal Stresses. By BRUNO A. BOLEY and JEROME H. WEINER. *Wiley, New York and London.* (124*s*)

During the past few years interest in thermal stresses has been stimulated by technical advances in the design of supersonic aircraft and missiles and, to a lesser extent, in nuclear power generation.

In the aircraft and missile field the source of heat is in the boundary layer of air which becomes heated because of its rapid change of velocity. The phenomenon is known as aerodynamic or kinetic heating.

The amount of heat flowing through the boundary layer and into the structure at any point will depend on the " heat transfer coefficient " and on the difference in temperature between the surface of the structure and the boundary layer. The temperature of the surface of the structure will itself depend on the heat flow characteristics of the adjacent structure in which conduction, rather than convection and radiation, plays the dominant role.

An essential preliminary to the calculation of thermal stresses is the determination of the temperature distribution throughout the structure; once this is known the designer can, in theory, calculate the thermal stresses, which must be combined with those due to inertial and air loads.

In this book the authors have presented a detailed discussion of the fundamental aspects of the theory of thermal stresses, of the background and the idealisations on which it rests, and have given solutions to illustrative problems. The book has been written for the research worker, the engineer and the student; it is divided into four parts of roughly equal size devoted to (1) the fundamentals of thermoelasticity, (2) heat flow theory, (3) practical thermal stress analysis in elastic structures, and (4) thermal stress analysis in inelastic structures.

The engineer may find Parts 1 and 4 heavy going because of the use of tensor notation. The style of presentation here is very much that of the mathematician, as the following short quotation will indicate: " Substitution .... into the equations of compatibility yields

$$\gamma_{prm}\,\gamma_{qsn}\,\epsilon_{rs,mn} = \tfrac{1}{2}\,\gamma_{prm}\,\gamma_{qsn}\,(u_{r,smn} + u_{s,rmn}) = 0$$

The equality to zero holds because (since u_r is in class $C^{(3)}$) the derivatives of u_r are symmetric in s and n and those of u_s are symmetric in r and m, whereas the respective permutation indices are antisymmetric in these indices ".

Attention in Part 1 is also given to uniqueness theorems and to the conditions under which mechanical and inertial coupling may be ignored. Part 4 includes a discussion of the theories of plasticity and visco-elasticity with applications to creep rupture, creep buckling and some simple (i.e. effectively one-dimensional) plastic stress analysis.

Parts 2 and 3 on heat flow theory and thermal stress analysis form virtually self-contained units which the engineer and research worker will find of great value. The Fourier heat conduction equation is treated in great detail together with the mathematical formulation of the various boundary conditions which may occur, including radiation and convection. Methods of solution of the heat conduction equation include that of separation of variables, use of the Laplace transform, conformal mapping and the superposition and imaging of sources and sinks. Approximate analytical procedures, including that due to Biot, are also given.

Energy methods that may be used for an approximate calculation of thermal stresses are presented, while exact analyses are given for some simple cases including straight and curved beams, and circular discs, cylinders and spheres in which the temperature at any point depends only on the radius.

The behaviour of plates subjected to temperature variations through the thickness and in the plane are also discussed; the buckling and post-buckling behaviour of such plates is touched on, as is the loss of torsional stiffness which will occur in a thin solid wing due to the action of spanwise thermal stresses. The corresponding loss of flexural stiffness has not, been mentioned.

A feature of the book is the number of detailed, and generally recent, references given throughout to the publications of over 300 different authors. The book is readable and well produced and can be recommended to engineers, research workers and students, though each will find (almost inevitably in a book of such all-embracing style) material that is not relevant to his own particular needs.

E. H. MANSFIELD

The Relentless Eye Watches

Understanding Organizational Behaviour. By CHRIS ARGYRIS. *Tavistock Publications.* (38*s*)

Less than 23 years to go.

One generation.

Enough time so that most of us will be around to see it and live in it. And weep? Or will there be a tiny last laugh left somewhere in—1984.

Today, looking bewilderingly about, we find that we are already the objects of a scrutiny that one generally associates with laboratory animals. Motivational research tells us what brand of margarine we are likely to smear on our breakfast toast tomorrow morning; pre-election polls, whom we will vote for two months hence and in what proportion; solemn-eyed statisticians mournfully assure us that, owing to heart disease, our ranks will be depleted by 22 per cent in the next ten years, 57 of us will be scraped off the roads next Whitsun, and only 4 per cent of the best Londoners read *The Times*.

We have become mere numbers, nameless bumbling sheep leaping clumsily over stiles, reduced to the absurdity of being the 0·1 of a 31·1 per cent statistic. Degrading. Humiliating. And damn well frightening.

Will and intelligence brought man dominance over the other animals.

Statistics begins to give man dominance over man.

And Mr. Big Brother creeps apace.

Mr. Chris Argyris is an associate professor of industrial administration at Yale. His book reads like it. Arranged like a Master's thesis, it crams tables, charts, perpendicular rows of numbers, IIA's, 3b's and (1)c(iii)'s into its 179 tortured pages. Occasionally, a good idea is buried amidst this academic rubble, but one has to proceed like a demolition expert to extract it. It uses interviews, conducted with the employees of two plants owned by the same group, as its material. The author then goes on to describe " diagnostic techniques " intended to guide future researchers.

Try this extract with subject for example; Mr. Argyris is speaking about the interviews with employees:

> " Even with the most 'objective' definitions of these factors, there is still a strong possibility that the interviewer can become defensive and attribute to the respondent feelings and needs that are really his. For example, the writer knows that as a result of studies of his own interviewing, he tends to ' see ' more aggression in situations than do other observers. He may decide that he wants to know why he does this (which he did decide) but this is not mandatory. If the people making the analysis know of his biases, they can account for them when they are analyzing the data that he obtains."

Wonderful. And who interprets the interpretations of the people making the analysis to account for *their* biases? How far does one carry this game, for some supposed objective of " scientific detachment "?

Good ideas occasionally emerge like pearls from the muck. As:

> " The impact of (organizations) is to place

employees in work situations where (1) they are provided minimal control over their workaday world, (2) they are expected to be passive, dependent, and subordinate, (3) they are expected to have the frequent use of a few skin-surface shallow abilities, and (4) they are expected to produce under conditions leading to psychological failure. All these characteristics are incongruent to the ones that relatively mature human beings in our culture are postulated to desire. They are much more congruent with the needs of infants in our culture. In effect, therefore, organizations adapt an initial strategy where they are willing to pay wages and provide adequate seniority if mature adults will, for eight hours a day, behave in a less than mature manner."

Here, I had to repress a shudder of recognition. I wondered about Mr. Argyris; he included I hope Yale and himself in this indictment; or isn't it cricket to apply deductions against the deducer?

One happy talent that the author possesses is in the colourful selection of factory-worker reactions that liven a basically dull presentation. Mr. Argyris has been talking about the workers' reactions to visits of management to the plant. He then produces the following sample:

"I think it's a wonderful thing. It gives people a big boost. If a person of higher standing walks through and is willing to put himself more on your level, and you're a lower-standing person, then you feel like really helping him. What the hell do you feel with a man who knows he has higher standing, and wants you to know it. You really don't like him, he's stuck-up. This is what I like about so many of our top people. They go around and they don't act like they're God. They act like they're one of us."

Or, in answer to a question regarding job-satisfaction:

"The only reason I work is to make more money. No other reason. Some guys, damn few, say they work for pleasure. They must be bats. How the hell am I supposed to get satisfaction from my job? I'd just as soon go out and dig holes. At least I'd be in the fresh air."

Foremen in the plants under study were in thankless positions, over half of them earning less than the average wage of the employees under their supervision. Their status, both in the eyes of management and worker, showed this. One worker, when asked if he would like one day to be a foreman, replied:

"Who, me, be a foreman? Are you kidding? What the hell do those guys do? They're not foremen, they're lackies."

Another, asked about job challenges, said:

"Challenge? Are you kidding, Doc, what kind of challenges are there on these jobs? Any dodo can do them."

But, unfortunately, this type of purely documentary material is rare. More often, the author is trying to explain what good the whole analysis is, who it can help, "conceptual strategies" used, and so on. These are fuzzy, undefined, and groping for meaning. Mr. Argyris even makes a plea in his preface hoping that "some of the readers will be kind enough to communicate their constructive criticisms and make suggestions for new directions."

This might be construed as admirable modesty. Or, cynically, as a desire for more mail. I put it down to mere confusion.

Mr. William F. Whyte has made a distinct contribution to his profession with the authorship of *The Organization Man*. Mr. Argyris may one day make a similar one.

Understanding Organizational Behaviour is not it. It really doesn't understand it.

DAVID CHAGALL

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Construction

Insulated Aluminium Sandwich Wall. ALCAN INDUSTRIES LTD., Bush House, Aldwych, London, WC2. Summary of product as a combination of aluminium with a standard insulating material to give an economical and efficient insulated industrial wall cladding of pleasing internal and external appearance. Brief details of construction. 4 pp. ill.

Plastic Piping for Underground Mains and Services. YORKSHIRE IMPERIAL METALS LTD., PO BOX 166, Leeds. An introduction to "New Polycore B" covering underground applications and including a flow chart, standard water pipe sizes, methods of jointing and general and technical data. 18 pp. ill.

Dovetailed Floor Flags. RUBERY OWEN AND CO. LTD., Whitegate Factory, Wrexham, N. Wales. Product described as a strong, permanent, non-skid flooring. Flags are 18 in by 12 in heavy gauge sheet steel with tangs to secure in position on concrete base. Installation details are provided. Double-sided leaflet, ill.

Stainless Steel Tubes. SANDVIK SWEDISH STEELS LTD., Manor Lane, Halesowen, Birmingham. Covers many aspects of stainless steel tubes, with detailed information on stainless steel grades, manufacturing methods, tempers and finishes, fabrication and welding. Mechanical strength of the company's tubes is dealt with and applications and working pressures are included. 175 pp. ill.

Core Drill Apparatus. SOILTEST, INC., 4711 W. North Avenue, Chicago 39, Illinois, USA. A new core drill rig for rugged field service, very deep core drilling and versatile operation is described. Folder, 6 pp. ill.

Trencher Attachment. BRAY CONSTRUCTION EQUIPMENT LTD., Faggs Road, Feltham, Middlesex. The Sherman trencher attachment is described and illustrated; the unit can be fitted to any of the maker's own shovels and to a wide range of loaders and tractors of other manufacture. All-condition stabilizers are fitted. Leaflet, 4 pp. ill.

High Discharge Truck Mixers with Hydraulic Drive. RANSOMES AND RAPIER LTD., Waterside Works, Ipswich, Suffolk. Describes truck mixer developments and the advantages of hydraulic drive. Detailed specifications of a range of models are given. Leaflet, 8 pp. ill.

Red Cedar Exteriors. J. E. LESSER AND SONS LTD., Green Lane, Hounslow, Middlesex. The "Middlesex" prefabricated building range is described, which incorporates red cedar cladding. Types of interior finish are also outlined. Double-sided leaflet, ill.

Safe Access in Industry. ACCESS EQUIPMENT LTD., Maylands Avenue, Hemel Hempstead, Hertfordshire. A folder containing a range of literature on access equipment, aircraft ground equipment, materials handling equipment and other products. Various leaflets, ill.

New Books

The Year Book of Technical Education and Careers in Industry, 1961. Edited by H. C. DENT. 5th Edition. *Adam and Charles Black.* (35*s*)

Information is given on facilities for scientific and technical education, careers open to young people in industry, how to train and enter for them, and the prospects they offer.

Mechanical World Year Book, 1961. 74th Edition. *Emmott and Company, 31 King Street West, Manchester 3.* (5*s*)

The 300-odd pages of this pocket-book are, as previously, crammed with a wide range of mechanical engineering information and data. Of special interest are the notes and tables summarizing the available methods for making direct and comparative precision measurements.

Year Book of the Heating and Ventilating Industry, 1960-61. 14th Edition. *Technitrade Journals Ltd., 11 Southampton Row, London WC1.* (15*s*)

Authoritative articles on radiant heating, thermal behaviour of buildings and boiler-water treatment preface an extensive reference section (covering, *inter alia*, heating and ventilating literature of 1959, conditions of trading, and consulting engineers) and a buyers' guide.

Newnes Electrical Pocket Book. Edited by E. A. REEVES. 15th Edition. *George Newnes.* (10*s* 6*d*)

The familiar pattern is repeated: over 50 short sections, interspersed with useful diagrams, graphs and tables, covering many branches of electrical engineering. Several recent developments are touched on, e.g. Bacon fuel cells, infra-red 3 micron heaters, pumped storage schemes in nuclear power stations.

Water Engineer's Handbook, 1961. 29th Edition. Edited by D. WILKINSON and N. SQUIRE. *Colliery Guardian Company Limited, 30 Furnival Street, Holborn, London EC4.* (20*s*)

Detailed information is given on the water undertakings of the British Isles and on all other leading authorites associated with the water industry. Listed are 222 undertakings affected by the regrouping carried out in 1960 and up to April 1961; details are also given of 24 new boards and companies which came into operation over the same period. Waterworks statistics, water treatment and hardness, and river boards are among the topics covered. A comprehensive buyers' guide is appended.

British Plastics Year Book, 1961. 31st Edition. *Iliffe.* (45*s*)

New in this edition (which is as comprehensive as ever) is a section listing firms giving basic services from moulding and extruding to welding and metallizing.

Guildhall Lectures, 1960. *Published for the British Association for the Advancement of Science and Granada TV Network Limited by University of London Press.* (4*s* 6*d*)

The three lectures collected here are the series given in Guildhall in September and October, 1960, under the general title "Communication in the Modern World." They are: *The language of the gene*, by Prof. G. W. Beadle; *Communicating with Caliban*, by Prof. H. J. Eysenck; *The human receiving system*, by Lord Adrian, O.M.

Foundations. By A. L. LITTLE. *Edward Arnold.* (100*s*)

In arranging this exposition of the theory and practice of foundation engineering, Mr. Little has divided the subject matter into shallow and deep foundations, the latter being further subdivided into those which are piled and those which are not. Much of the book is concerned with case records.

Design and Construction of Ports and Marine Structures. By ALONZO DEF. QUINN. *McGraw-Hill, New York and London.* (£6 4*s*)

The essential concepts in the designing and building of shipping-terminal, harbour and off-shore marine structures are brought together, along with the working principles and practices that can be adapted to specific project requirements.

Monorails. By HERMANN S. D. BOTZOW, JR. *Simmons-Boardman Publishing Corporation, New York; Ian Allan Limited, Craven House, Hampton Court, Surrey.* (21*s*)

Objective assessment of the potential of monorail transportation in the US, with descriptions of various types of monorail, tracks and structures, cars, stations and wayside equipment. Economics are considered, too. There is a short discussion of every known operating monorail service and a bibliography of 450-odd items.

The Reviewers

Mr. P. Hammond, M.A., M.I.E.E., A.M.I.Mech.E., is a lecturer in engineering at the University of Cambridge.

Dr. T. I. Williams M.A., B.Sc., is a fellow of the Royal Institute of Chemists and editor of the I.C.I. magazine "Endeavour". One of his interests is the history of technology.

Dr. E. H. Mansfield, F.R.Ae.S., is a senior principal scientific officer in the Structures Department of the Royal Aircraft Establishment, Farnborough. He is also the author of numerous research articles on structures.

Mr. David Chagall is a novelist. His first novel *Diary of a Deaf Mute* has been published in several languages, his second *The Century God Slept* is shortly due to appear. He is a *licencié* of the Sorbonne and graduated from the Pennsylvannia State University in physics and psychology. He has worked on the advertising staff of a large American pharmaceutical corporation and as an assistant editor of an electrical journal.

Marketing

Consumer Goods on Show at Leipzig

EVEN more so than has been the case at past exhibitions, variety will be the keynote of this year's Leipzig Autumn Fair from 3 to 10 September. It is being divided into no fewer than 30 sections, covering most types of consumer goods. These will range from leather products and glassware to artificial flowers, and from pharmaceuticals and special kinds of paper to teaching aids.

The autumn Show is a "Sample Fair" devoted to consumer goods. So far 19 British firms have booked space, showing an area increase of some 25 per cent compared with 1960. Machinery and capital goods are on display at the larger Spring Fair.

Some 115,000 sq. metres of floor space will be taken up by the exhibits and all sections of the fair will provide for a large measure of international participation. Many of the sections, having regard to the variety and international character of their exhibits, will have something of the nature of specialized trade fairs in their own right. The largest of the sections will be that dealing with textiles and clothing, in which exhibitors from 23 countries will take part.

In other sections, there will be numerous examples of light engineering products: office equipment, radio and television sets, sound-recording apparatus, electronic and electrical measuring instruments, domestic refrigerators, sewing machines and cameras. Among the larger types of products to be on show, may be mentioned road vehicles—of many kinds—and motorboats.

In the United Kingdom, the agents for the fair are the Leipzig Fair Agency in Great Britain, whose address is 39 St. James's Place, London SW1.

Sweden Chooses Bristol Bloodhound

The largest contract yet placed for a British guided weapons system by an overseas government has been received by the BRITISH AIRCRAFT CORPORATION. The Royal Swedish Air Force Board has ordered, at a cost of "many millions," an unspecified number of Bristol Bloodhound Mk. 2's for the air defence of Sweden, after a careful and lengthy evaluation which included not only the British weapon but also American contenders.

Announcing this recently, Lord Caldecote, executive director (guided weapons) of the British Aircraft Corporation, said that competition had been "very, very fierce" and it was significant that a country such as Sweden, which was in a position to make a decision based solely on the merits of the weapons concerned, had selected Bloodhound Mk. 2.

The Royal Swedish Air Force Board said "The adoption of Bloodhound 2 into the Swedish Air Defence System will complete our fighter defence and will give it higher efficiency since this guided weapons system can be used against targets at the highest and lowest altitudes and gives a very high degree of readiness at a reasonable cost."

In September, 1958, Sweden ordered a batch of Bloodhound Mk 1's so that experience could be gained with surface-to-air missiles in air defence. Since then, intensive studies and evaluation work on technical and operational aspects of this weapon system have been undertaken. As a result Bloodhound 2 has been ordered.

The later Mark, which closely resembles Bloodhound 1 in external configuration, offers greatly improved performance—greater range and lethality and greater operational flexibility. An important factor in these improvements is the use of continuous-wave radar guidance developed in conjunction with the Ministry of Aviation by Associated Electrical Industries and Ferranti. Bloodhound's radar range has been extended and the weapon is effective against targets even at very low altitudes and in the face of highly sophisticated electronic counter measures.

Lord Caldecote stressed that development of Bloodhound had been a real team effort between the Aircraft industry and the Ministry of Aviation. The companies concerned are Bristol Aircraft (weapons systems managers), Ferranti, Associated Electrical Industries and the power plant manufacturer, Bristol Siddeley Engines.

Czechs Plan their Engineering Industry

Addressing a meeting of the Industrial and Foreign Committee of the Czech National Assembly on 7 July, Mr. Frantisek Krajcir, Minister of Foreign Trade, outlined the present and future plans of the Czech engineering industry.

He said: "In 1960 our engineering industry accounted for 45 per cent of our total exports. The contribution of the industry in the total economy rose to 33·7 per cent against 28·8 per cent in 1955. This represents an actual productive increase in the industry of 94 per cent.

"We now take third place, after the USA and Western Germany, in engineering production capacity per capita.

"The priorities in our present five-year plan are as follows: steel mills, chemical plant, power stations, machinery for the building trade, transport, and machinery for the food industry.

"At the moment we are producing 80 per cent of all the types of machines and machine tools in world production. This amount of diversity is unsatisfactory and the percentage must be reduced. This will be accomplished by unification, rationalisation and normalisation of the engineering industry.

"Between 1956 and 1960 exports of engineering products increased by 70 per cent to a value of 6,300 million crowns. In 1937 exports were 1 per cent of world trade in engineering products, in 1960 they were 3·2 per cent.

"Our imports of engineering products are also rising rapidly, particularly in 1960, from such highly industrialised countries as Britain, West Germany, Austria and France.

"In West Germany we now take third place as exporters of machine tools.

"During the third five-year plan until 1965 we intend to increase the whole of our foreign trade by 47 per cent. Our imports of engineering products will increase in the same period by 80 per cent.

"As far as Britain is concerned, we wish to increase our imports of machine tools and capital equipment for those industries to which we have given priority.

"Looking further ahead to the next twenty years the main accent will be on the development of the heavy machine industry. By 1980 we expect the engineering industry will account for 73 per cent of total exports. At the same time our imports of machinery will increase by at least 100 per cent on the present figures, and will represent 43 per cent of our total imports."

The third International Trade Fair, which specializes in engineering products, is to be held at Brno from 10 to 24 September. Last year the attendance was over 3½ million and there were visitors from 81 countries.

When is a Vending Machine—?

It looks as if the rapid progress of vending machines may run into a road block quite shortly. As a result of recent talks between the London County Council and London borough councils it was decided that automatic vending machines are "structures" for planning purposes, and an official of the London Councils Standing Committee said that they were advised "that there is good ground for saying that such machines are structures within the meaning of the Town and Country Planning Acts 1947-59 and that their provision constitutes development within the meaning of those Acts." In certain circumstances the machines also fell within the Lamp and Sign byelaws.

More and more automatic machines are being installed and the range of items sold is also increasing. In France you may buy a bag of coal from a machine and in England you can get a canful of paraffin (Esso-Blue). You have to provide your own container however. Vending machines offer a service to the public at times when a shop service would not be operable and in situations where a shop would not be suitable or economical. But some are noisy and those that dispense wrapped goods, including drinks, can add greatly to the litter menace. It was in fact as a result of complaints that the talks referred to above were originally called. The decision that the machines come within the Acts could bring their siting and operation under a strict control.

Bitish Contractor Wins $1 million Contracts

Contracts worth about $1 million for the construction of two avalanche sheds over the Trans-Canada Highway near Lanark in British Columbia have been awarded by the Provincial Department of Highways to JOHN LAING AND SON (CANADA) Limited.

The sheds are designed to safeguard the highway from avalanches and maintain an all-weather route through this part of the Rocky Mountains. Work began recently and must be completed by early November this year if danger from avalanches is to be avoided.

The method of construction will be by *in situ* reinforced concrete and precast concrete units, of which over 1,700 are to be used, including about 300 precast prestressed roof beams, each weighing 17 tons. Over 15,000 cu. yd of excavation, much of it in rock, will be necessary in connection with the projects and about 600 tons of reinforcing steel are to be used for the concrete. The consulting engineers acting for the Government of British Columbia are Choukalos, Woodburn, Hooley and McKenzie.

Last year the company won a similar race against time by the completion in only 3½ months of a 1,036 ft long avalanche shed in the same area.

Britain: India's Industrial Partner

An official United Kingdom exhibit is being provided by the Board of Trade for the Indian Industries Fair, the international trade exhibition in New Delhi, which is due to open on 14 November and will continue until 1 January next year.

A site for this purpose, covering some 66,000 sq. ft, has been taken by the Board and the United Kingdom pavilion now being constructed will occupy about two-thirds of this area. The pavilion will have two main sections, one of which will be devoted to the official exhibit. The object of this exhibit will be to emphasize the continuing and important contribution which Britain is making towards the industrialization of India and it will incorporate sections on finance, transport, communications, power, health, knowledge and commercial production.

The second section of the pavilion will comprise a commercial display, in which British firms and Indian firms with British connections will arrange individual displays of their products on stands to be provided by the Board. Some 26,000 sq. ft have been allotted to this section, sufficient to accommodate 49 firms inside the pavilion and two in the open air. Ten other firms with British interests will exhibit independently in their own pavilions on adjacent sites.

A model of the United Kingdom pavilion, which was recently on view in London, is shown in the accompanying illustration. Structural units for the pavilion are being supplied by Taylor Woodrow (Building Exports) Limited.

Societe Genevoise Jig Boring and Milling Machine

This outstanding machine owes its existence to a Swiss firm now in its hundredth year. It started life as a small bench mounted tool.

THE Societe Genevoise Hydroptic-6A Jig Borer is a perfectionist. It is the envy of other less fortunate machine tools created around a market rather than around a new, badly needed function. For the jig borer is simply a machine tool making it possible to bore in any given workpiece a hole *exactly* where it is intended. Strangely enough, no machine existed prior to its introduction in 1921, able to fulfil this seemingly obvious requirement.

The jig borer was born of a Swiss instrument firm that was struggling for its existence during the slump following the First World War. Right at the start of its career it had to become the principal breadwinner of its originators.

All too often the twin qualities of inventive genius and technical ability fail to gain recognition because they are misdirected. The invention fails, either because it is not wanted or because it cannot be economically produced. Here we have a striking exception. A steady stream of brilliant ideas emanating from within the organization have been poured into the SG jig borer, all effectively directed at making it a more accurate and useful machine. To this factor must be added a background of characteristic Swiss technical talent, determination and capacity for hard work.

The Societe Genevoise d'Instruments de Physique, of Geneva, Switzerland, was founded in 1862 by a wealthy scientist called Auguste de la Rive. He took as his partner another scientist called Marc Thury who owned a small workshop for making optical equipment; and who turned out also to be a brilliant engineer. Between them they built up a gradually expanding business repairing and making scientific instruments.

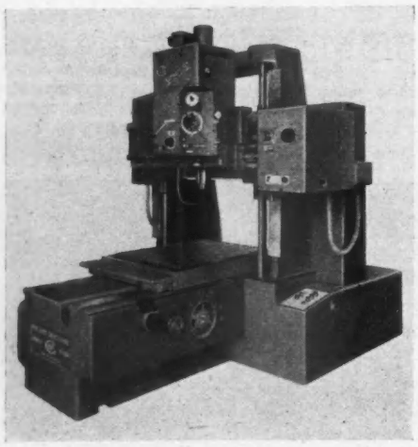


Fig. 1 The Hydroptic-6A, 1958.

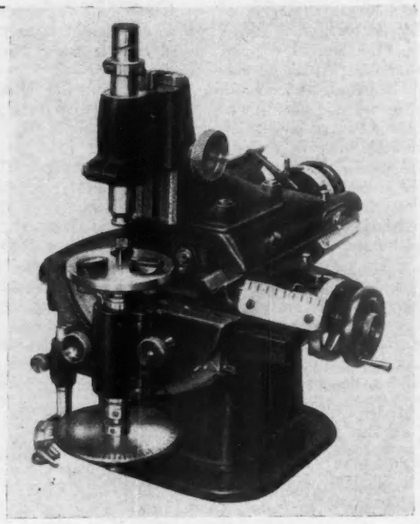


Fig. 2 The " machine à pointer."

By 1907 both the original founders had died and the company was producing a variety of instruments, also dividing engines. The year was important for the appointment as engineer of young Fernand Turrettini. It was he who was later to guide the company into the field of vertical jig borers, the future principal activity.

After the war, trade declined sadly and the company would probably have gone out of existence had not the thriving Swiss watch industry approached them with a request for a machine for accurately marking out the drill jigs for fixing the spindle positions on the top and bottom plates of watch movements. The result, developed by Turrettini, was the " machine à pointer " or pointing machine—the small bench mounted tool shown in Fig. 2. The hole centres were positioned by means of micrometer drums and lead screws with the new famous pitch correcting device.

Leading Particulars of the Hydroptic-6A

Capacity (table × spindle head travel)	40 in × 28 in
Table working surface	43½ in × 33 in
Net weight (with standard equipment)	21,000 lb
Maximum table load	2,200 lb
Spindle motor hp	8 hp plus 50 per cent overload capacity
Drilling capacity from solid	2⅜ in diameter
Boring capacity	12 in diameter
Milling capacity	10 in diameter face milling with inserted teeth and negative rake
Guaranteed accuracy for all displacements of table and spindle head saddle	0·00015 in

The logical development of the pointing machine was the provision of flexible drive to enable the holes to be both marked out and drilled on the machine. Then the machine was enlarged into the two column vertical jig borer, the basic design of which remains unchanged to this day. Only in the two smallest sizes has single column construction been maintained.

In the transformation, the drilling head, instead of being mounted on a single movable pillar, was mounted on a crossbeam or "bridge" spanning the table and supported by two fixed columns, one each side. The head was capable of being traversed along the bridge, and positional determination in the other direction was provided by making the table movable along its axis. Fig. 3 shows the first industrial model which appeared in 1921, the MP-4, which had a capacity of 18 in by 24 in.

The introduction of the jig borer at once revolutionized jig making; it facilitated the work of the skilled toolmaker by improving his accuracy while at the same time increasing his output. The first SG jig borer was sold in this country, to the Royal small arms factory at Enfield near London, and the second went to Brown Boveri in Switzerland. The machine was an immediate success.

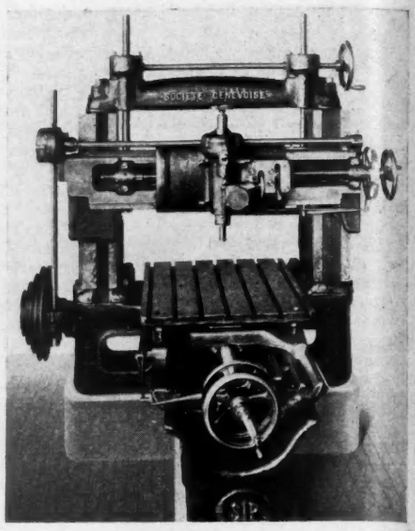


Fig 3. First industrial jig borer, the MP-4, 1921.

In 1923 came the MP-5, a larger machine with a capacity of 32 in by 24 in. It had a secondary spindle for drilling small holes outside the capacity of the main spindle. The MP-5, too, made its debut in England, at the works of Metropolitan Vickers in Manchester. Another of the early MP-5s went to the Ford Motor Company at Detroit, subsequent purchaser of no less than 18 SG jig borers. At this point it is worth remembering that each borer was then, and still is, essentially a hand-made, precision machine tool; in a sense, a scaled-up version of the accurate measuring instrument, strengthened to withstand machining loads.

Perhaps the success of the scientific instrument firm in entering the machine tool industry is due in greatest part to having had no preconceived notions about machine design. A purely scientific approach coupled with painstaking attention to technical detail had succeeded in producing both an original and at the same time almost indispensable tool.

The story of the development of the SG jig borer from the MP-5 up to the Hydroptic 6A—and the 6 other machines produced today—is

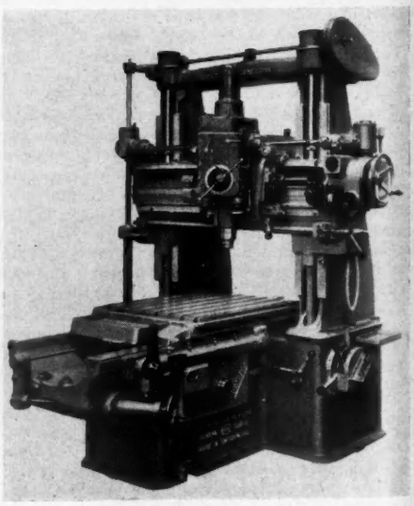


Fig. 4 The Hydroptic-B, 1934.

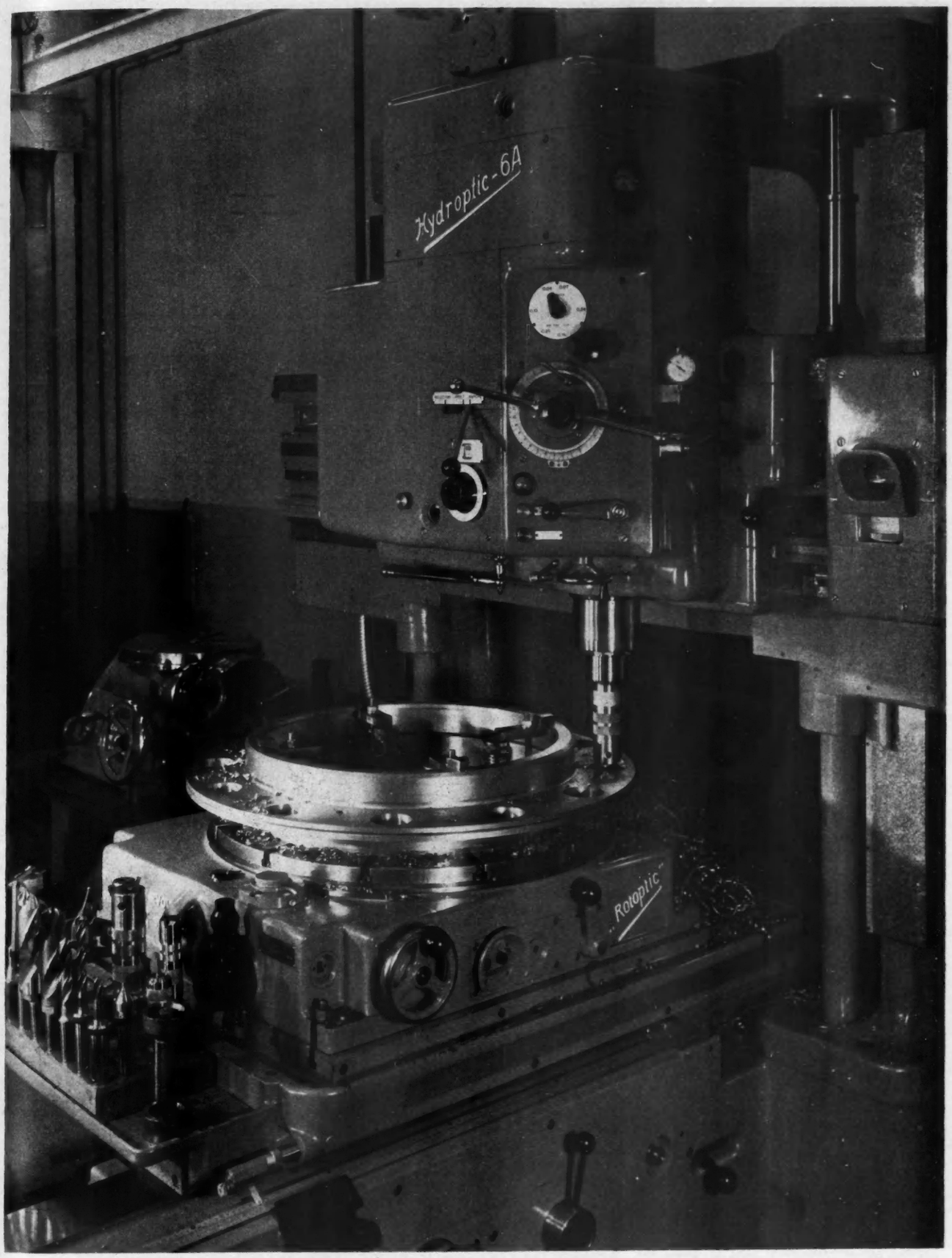


Fig. 5 A surprise departure from a traditional line led to the evolution of an indispensable machine.

one of successive refinement. Each stage in the evolution represented a technological advance ment aimed specifically at increasing the inherent usefulness of the machine—the culmination of years of painstaking development.

Throughout all the SG jig borers runs the common thread of technical excellence and originality, shown by the following features:

Pitch Correcting Device.—This device, designed originally by Thury, compensates for the lead screw pitch errors. It rotates the micrometer drum vernier by an amount which eliminates the error at the position in which either the table or the head is being set. The amount of rotation is controlled by a lever in contact with a metal template, in the ratio of 200 to 1.

The template is made individually for each lead screw from a chart prepared by means of a high precision standard scale read with a microscope. The table or head is displaced by regular intervals of ½ in (or 1 cm) and the error from the true position is measured and plotted.

Guideway alignments. SG realized that the weight of the table on the bed produces a small but determinable deflection and took steps to eliminate its effect. The guideways are finished with a slight degree of convexity, the amount varying with the size of machine. The increase in height at the middle of the guideways is never more than a few ten thousandths of an inch, with a correspondingly small tolerance.

For the sliding surfaces SG use a particular method of draw-scraping in which the workman creates small depressions less than 0·0001 in deep and of uniform shape. The depressions provide an excellent surface for oil retention, minimizing friction losses and hence facilitating accurate setting; and also afford the means of establishing the desired curvature. Consistency of quality is maintained by a combination of skilled labour and accurate inspection.

HYDROPTIC MACHINE

The manufacture of jig borers expanded rapidly, and in 1928 a large assembly shop was erected. During this year 112 machines were sold. In 1933 came the MP-6B, the first 3-co-ordinate jig borer permitting, at one set-up, the machining of all but one faces of any workpiece.

The Hydroptic machine (implying a combination of hydraulic table drive and optical setting) was perhaps the most important intermediate stage in the jig borer's development. It sprang from the realization in 1931 that the machine's scope would be greatly increased if it could be adapted to carry out high precision milling operations without detriment to its life, accuracy, or efficiency as a boring machine. Two major problems had to be solved:—

(1) The spindle bearings had to be redesigned to take the heavy lateral thrust of the milling cutter as well as the pure vertical thrust imposed by boring operations.

(2) The measuring system had to be divorced from the means of moving the table and spindle head, since using the table lead screw to provide the feed for milling would quickly destroy the established accuracy of measurement.

The first problem was one of mechanical design and manufacture. The company finally decided to set up a special department to produce taper roller bearings of their own design, to provide long life and accuracy. The guaranteed concentricity was eventually narrowed to within one micron (0·00004 in); spindle speeds were increased and the secondary high speed spindle could be eliminated.

The second problem involved a question of policy. The decision was made to utilize for measurement the principle of the high powered microscope, already used by the firm in the preparation of the pitch error device templates.

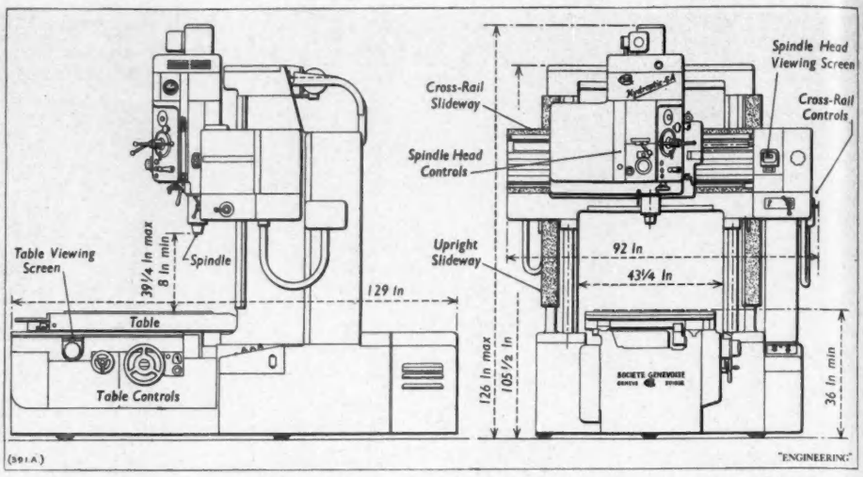


Fig. 6 Drawing of the Hydroptic-6A showing principal features and control positions.

Its inherent accuracy would be unaffected by wear and tear and, being built in, the microscope would also be extremely unlikely to be misused by the operator—just the sort of considerations that appealed to a company like Societe Genevoise, schooled in instrumentation techniques.

Lastly, a new table drive was designed using a hydraulic ram in combination with a short portion of leadscrew and handwheel for fine setting. These schemes reached fruition in 1934 when the Hydroptic-B, the outcome of three years of intensive development work, was exhibited at Olympia, in London. Almost at once a big expansion in business commenced.

Perhaps the next important development occurred just before the Second World War when rollers were introduced in the larger machines to reduce the effort required to move the table. After the War came the Hydroptic-7, the largest jig borer so far, with a capacity of 55 in by 40 in, and it was followed shortly afterwards by the Hydroptic-8 with three coordinates; but it is the Hydroptic-6A which has been chosen for this Product Profile because it may be regarded as being the epitome of Societe Genevoise jig borer in terms of sophistication and popularity. Its lineal descent from the Hydroptic-B can be traced through an intermediate model, the Hydroptic-6, which is famous for having introduced yet another big improvement. The microscopes focusing on built-in standard scales were replaced by small projection screens let into the bed and crossbeam. The screens made life much easier for the operator who no longer had to stoop over the microscope and close one eye. The screens have since replaced the microscopes on all the optical machines, see Fig. 7.

About three years ago Societe Genevoise became actively interested in automatic machine tool operation. They recognized that in a precision tool like the jig borer the human element could not be entirely divorced; but there was still no reason why the operator should not receive some assistance. Since the jig borer is sometimes used for accurate series reproduction, there is an incentive to offer equipment which will successively and accurately repeat the settings made by the operator while making the first workpiece. Thus he is relieved of the purely repetitive part of his task and can use the time saved to prepare his tooling. The company offer the large jig borers, the 6A and 7A, either with or without repeating equipment to suit the customer. When fitted it is possible to repeat the initial setting within one micron, far more accurately than a skilled operator could do so.

A further concession to the cult of automation, more recently introduced, is the optional provision of punched tape control.

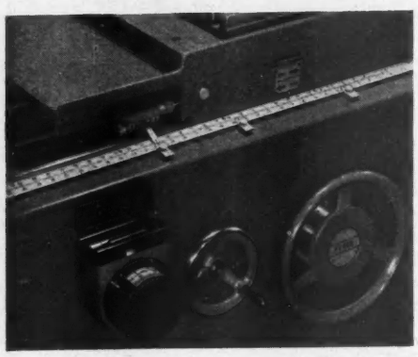


Fig. 7 Graduation lines on the totally enclosed standard scale are magnified and projected on to the viewing screen (bottom left). The auxiliary scale shown is for rough setting.

ENGLISH COMPANY

One of the first steps taken by SG when they started producing jig borers was to establish a foothold in this country. They initiated Societe Genevoise Limited in 1921 specifically to sell jig borers, which company remained independent until 1955. Another company provided service facilities and the enterprise was so successful that out of a total of about 5,200 machines made altogether, no less than 1,000 of them are in use in Britain today.

During the Second World War, keeping them running despite the possible effect of enemy action was considered of such importance that the Government approached the English company with the suggestion of setting up a factory with facilities for repairing and rebuilding damaged machines. The result was the establishment of a small works in Buckinghamshire that gave way a few years later to a much larger one at Newport Pagnell. Production of the smaller jig borers is now well established, and though not yet in sufficient quantity to meet this country's demand, expansion of facilities continues progressively. The English concern is still the only foreign subsidiary with its own manufacturing capacity.

Despite the exceptional manufacturing precision embodied in the SG jig borer, very few parts are imported from Switzerland, other than the spindle head which arrives complete. The same atmosphere of precision pervades the assembly shop at Newport Pagnell, in the heart of rural England, as characterizes the factory at Geneva—where, incidentally, precision line scales for non-industrial purposes are also made.

Sponsored Production Research Pays Off

Having terms of reference with some degree of flexibility, and a wide range of activities, the Production Engineering Research Association is making rapid progress.

During the past year, there has been a substantial increase in the number and scope of sponsored research and sponsored advisory projects carried out by the Production Engineering Research Association.

In all, 226 sponsored research projects were completed and 218 new projects were started, covering virtually all aspects of production as well as the design, development and manufacture of special-purpose equipment. Typical assignments included the measurement and analysis of sources of vibration in machine tools and other equipment; redesign of products for cheaper production; development of tooling for cold extrusion, finish blanking and finish piercing; and the installation of planned maintenance schemes and automation projects ranging from the development of handling gear to complete systems for component manufacture.

Some firms have also appointed PERA staff as members of production efficiency groups, development committees, etc., at the member's works to advise on specific production problems and various aspects of broad planning.

As a result of such assignments, a number of member firms have reported some very substantial economic gains. For example, following a critical survey of methods, tooling, plant and production design in one company, a net saving of £20,000 was made in the machine shop alone in the first year. This was in addition to several smaller but nevertheless valuable savings in other departments. Another member firm raised its factory efficiency by about 120 per cent as a result of an exhaustive investigation into all the firm's production activities.

Remote Control Lathe

Among the work carried out in the PERA laboratories at Melton Mowbray during the past year was a project to develop a remote control copying lathe for work on radio-active components. This lathe, which has in fact cut the machining time for uranium components from one day to thirty minutes, is now undergoing simulation trials before machining tests are carried out on irradiated material.

A number of difficult problems had to be solved in the design of the lathe. For example, the need to enclose the cutting area completely in order to prevent swarf and cutting fluid from escaping into the surrounding area restricted the movements of the tool-post and created machining difficulties. It was also necessary to devise an unusually rigid structure and rigid tool and work-holding devices, in addition to ensuring that the working temperature was kept at a minimum in order to achieve the high workpiece accuracy and fine surface finish specified.

Lack of reliable data on the optimum cutting conditions, suitable cutting tools and cutting fluids, etc., for machining irradiated uranium also presented some unprecedented problems in determining the optimum machining cycle. These points were finally resolved on the basis of lengthy and exhaustive machining experiments.

Except for one or two simple controls, all the lathe functions are manipulated from a console desk which can be remotely located at a distance of up to 25 ft from the lathe itself, the only connection being a single cable harness.

Sponsored Research Dividends

The considerable economic gains which have resulted from the application of PERA's recommendations after carrying out sponsored investigations appear to have convinced many member firms that immense opportunities exist for big reductions in costs at all stages of manufacture. Industrial managers have increasingly recognised that such reductions can be quickly and easily achieved by using externally based specialists who are supported by physical research facilities and comprehensive information services. An objective analysis (reported by PERA) of recent trends in the growth of PERA's sponsored work has indicated a considerable expansion in member-firm's future needs for direct technical assistance from sponsored projects.

TABLE:—*Examples of Sponsored Projects*

Objective	Assistance provided by PERA	Results
To reduce cost of producing steel transmission units	After alternative methods of manufacture had been investigated in PERA laboratories, a cold extrusion process was adopted. Detailed techniques and tooling were developed.	Saving of £75,000 per annum on direct production costs. Material consumption reduced by half.
To concentrate production of mining gear into a building half the size of existing works to obtain space vitally needed for further expansion in heavily congested industrial area; to treble output; and to reduce manufacturing costs.	Improved tooling developed, cutter life increased by using more effective cutting fluids, machine tools improved, factory layout revised and materials handling improved.	Output increased by 3½ times in less than half the previous floor space. Equipment costs recovered in less than 15 months. Savings of approximately £20,000 per annum achieved in first full year.
To reduce cost of producing nuclear reactor fuel canisters previously produced by a series of costly conventional machining techniques.	Tools and techniques developed for producing canisters by cold (impact) extrusion in single operation.	Cost of production reduced to less than one-tenth of original machining cost.
To reduce number of operations needed for the production of steel automobile components in order to release operators and presses for other urgent work.	PERA finish blanking techniques applied.	Number of operations reduced from eleven to one, freeing several presses and operators. Production cost reduced to 10 per cent.
To reduce the cost of producing rectangular containers.	Product design and material modified to facilitate production by cold extrusion. Tools designed and technique developed.	Production cost per batch reduced from £9,500 to £2,500. Five power presses were released for other work. Inter-stage handling and heat-treatment operations eliminated. Material consumption reduced by 40 per cent.
Reduce cost of producing lens holders and increase rate of production to enable a British company to compete successfully in foreign markets.	Machining methods were modified. Practical tests were carried out to establish a suitable automatic cycle, and completely automatic plant was developed.	Automatic equipment operated by one man replaced ten conventional machines operated by ten operators. Rate of production increased 16 times, and manufacturing cost reduced to less than half.

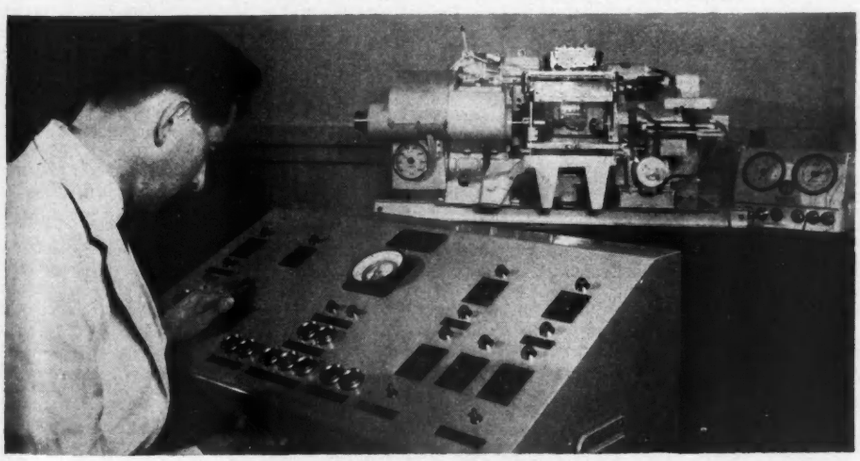
Cooperative Research

Valuable benefits seem to have accrued from successful coordination of the broad objectives of relatively long-term cooperative research with the more immediate aims of short-term investigations on particular problems. For instance, sponsored investigations have often expedited the progress of general research by providing opportunities for the investigation of specific problems which threw new light on the general development of techniques and equipment. Results obtained in the course of sponsored assignments have also indicated fruitful new lines of general enquiry, and the results of a number of private investigations have been published for the benefit of Association members generally.

New Building

Progress has been maintained at PERA on the construction of a new building for research applications and technical service, and it is expected that completion will be early next year. This building will provide laboratories, model workshops and offices to deal with the problems of effectively applying research results in industry; a multi-purpose hall for exhibitions, conferences, lectures and demonstrations; a comprehensive central library; laboratories and model workshops for work study and works engineering studies into mechanical handling, factory layout, etc.; and design and drawing offices. The completion of the building will make it possible to expand existing services and to meet the predicted demand for more extensive technical assistance that will be required by member firms in the future.

An idea of the trend in membership of the association can be gathered from the latest PERA Annual Report, in which it is stated that 58 new members joined during the past year. This brings the total membership up to 900. Between them, the member firms represent a very wide range of products—from nylon fabrics to nuclear reactors. The annual report also states that, in the last year, income increased by £62,035 to a figure of £403,873.



A remotely controlled lathe has been developed to machine uranium.

Plans For A Large Electron Microscope

Britain may soon possess a 1 MV electron microscope. Among many exciting possibilities, it may enable research workers to see individual atoms and to study living tissues, with a resolution of 1 Å.

By A. Franks, Ph.D., F.Inst.P., and J. S. Halliday, Ph.D., F.Inst.P.

In the last decade the electron microscope has become an essential tool in many research and industrial laboratories, providing a means of achieving much higher resolution and magnification than is possible with the optical microscope. In the electron microscope (Fig. 1) the electrons are produced at a heated tungsten filament and accelerated by application of a high voltage. These accelerated electrons are focused on to the specimen by the first one or two of a series of electromagnetic lenses (the condenser lenses) which form part of a cylindrical column. An enlarged image of the specimen is then formed by an objective lens and is further enlarged by one or more projector lenses. The final electron image may be photographed or viewed on a fluorescent screen. The whole apparatus works under vacuum, and air locks are provided for introducing the specimen into the vacuum.

The maximum accelerating voltage at present provided on commercial electron microscopes is 100 kV and, because matter is so opaque to electrons, the maximum useful specimen thickness is limited to a few thousand Ångstroms (1,000 Å = 10^{-5} cm, or 4 micro-inches). This limitation severely restricts the value of the electron microscope for metallurgical studies. Another limitation is that in studies of polymers and biological materials, the specimens may be degraded or destroyed as a result of the electron bombardment and exposure to vacuum.

It is possible to overcome or at least to reduce these limitations by increasing the electron accelerating voltage above the conventional value of 100 kV, and in the past two years four such microscopes have been constructed abroad. Details have been published of a 300 kV Japanese microscope[1] and a 400 kV Russian microscope.[2] A 350 kV microscope has also been constructed in Japan[3] and experiments with metallurgical specimens[4] indicate that the maximum thickness which can be examined increases approximately in proportion to the accelerating voltage. In France, Dupouy, Perrier and Fabre[5] have recently built a microscope (Fig. 2) to function ultimately at 1·5 MV and it has been used at voltages somewhat less than 1 MV. The high voltage generator (Fig. 3), an unpressurized Cockcroft-Walton set 31 ft high, is housed in a large hemispherical building 70 ft in diameter. The microscope column is over 8 ft high and weighs about 4 tons. Dupouy, Perrier and Durrieu[6] report that live bacterial specimens survived examination at 650 to 750 kV in a special chamber at atmospheric pressure and in saturated water vapour.

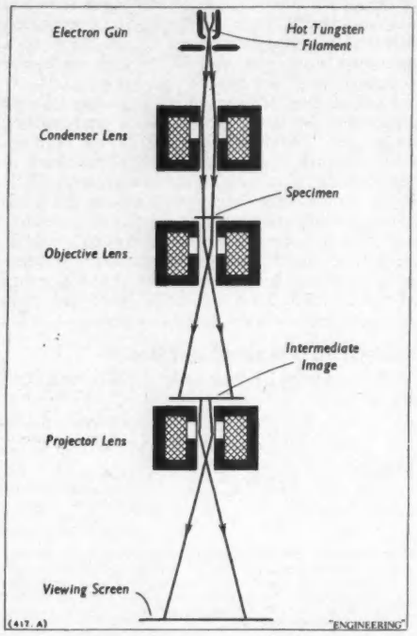


Fig. 1 Schematic diagram of electron microscope.

In order that Britain might play a full part in the solution of the problem, the Director of the National Physical Laboratory appointed a committee consisting of five scientists (see list) to investigate the feasibility of constructing a high voltage electron microscope capable of examining substantially thicker specimens, and this article provides a short review of their findings.

Two schemes have been submitted to the Department of Scientific and Industrial Research for building high voltage electron microscopes in this country. One of these would consist of a joint undertaking between the National Physical Laboratory and Associated Electrical Industries Limited and the other would be for a microscope in the Cavendish Laboratory. The joint NPL-AEI project is aimed at constructing a 1 MV microscope having a theoretical resolving power of between 1 and 2 Å which is comparable with the dimensions of the atom; this would be considerably in advance of any instrument now in existence.

Advantages of a High-Voltage Microscope

As already indicated, one advantage, and perhaps the major one, of higher accelerating voltages is the greater specimen thickness through which a high quality electron image can be obtained. At 1 MV it should be possible to examine undried biological specimens of about 1 micron thickness and metal (crystalline) foils from 5 to 10 microns thick.

A second advantage is that specimen damage, resulting from some of the electron scattering processes in the specimen, should decrease proportionately as the voltage is raised. In these "inelastic" scattering processes an atom in the specimen may be ionized or its electrons excited to higher energy levels. With metals such processes leave no permanent damage but in organic substances they can lead to considerable changes, for example, causing loss of crystallinity and cross-linking in plastics. Another form of damage will occur when the incident electrons are sufficiently energetic, causing displacement of atoms. For example, copper atoms will be displaced from their normal lattice positions when the accelerating voltage is greater than 500 kV. This sort of process may provide rewarding study in a high-voltage microscope.

A third important advantage, which will be much more difficult to achieve, is that the instrumental resolving power should improve as the voltage is raised. On theoretical grounds a twofold improvement in the ultimate resolving power would be expected on going from 100 kV to 1 MV, being slightly greater than 1 Å at 1 MV. Unfortunately, other factors, in particular the mechanical and electrical stability of the microscope and its supplies and also electron energy losses in the specimens, can easily set a poorer practical limit to the resolution. However, the influence of energy losses decreases as the voltage is raised so that the prospect of approaching the theoretical resolving power is enhanced. If the requisite mechanical and electrical stabilities can be obtained and sufficient contrast is available, it should be possible to see crystalline lattices in metals and plastics and perhaps the individual atoms in thin non-crystalline specimens.

Some Applications

Naturally, the most useful applications for high-voltage microscopes stem from the advantages just described. For convenience they are considered separately for metallic and non-metallic specimens.

Metallic Specimens. The microstructure of bulk materials can be studied either by a replica technique, for which existing instruments are perfectly adequate, or by transmission of the electron beam through a very thin specimen. Usually such thin specimens are prepared from bulk material which has been subjected to some chosen process, such as deformation or heat treatment. Reduction of the specimen thickness is carried out in a number of stages, the final reduction to a few thousand Ångstroms being accomplished by a delicate electro-polishing procedure. There is some evidence that the microstructure may alter, possibly due to release of internal microstresses, while the final thinning necessary for observation at 100 kV is carried out, so that the specimens do not always represent the microstructure of the bulk material. It is also known that mechanical properties such as stress-strain relationships are different in thin specimens. Consequently, some of the advantages resulting from using thicker specimens are:

(1) The results obtained from examining specimens 5 to 10 microns thick will bear a much closer relationship to those of bulk material, and should therefore be more applicable to materials of engineering interest.

(2) Specimen preparation is much simpler.

(3) There is less likelihood of phases, e.g. carbide particles in steel, dropping out of the specimen due to preferential attack by the electrolyte.

(4) Specimens can be prepared directly by standard procedures such as rolling or extrusion, and this may be of considerable interest to the foil and wire industries.

(5) Experiments carried out within the electron microscope, for example to study the basic dislocation interactions such as the intersection and cross-slip of dislocations or the reaction between a dislocation and a precipitate, would become more realistic. The thicker the specimen the easier it is to ensure uniformity in thickness and to reduce the importance of surface tension and surface contamination forces, so that a known stress can be applied to the dislocations.

(6) Some phenomena such as twinning and martensitic transformations are dependent on the geometrical constraints of neighbouring

Research Report

on a joint NPL and AEI project to design and build a 1 million volt electron microscope

Committee of Investigation

Dr. V. E. Cosslett, Cavendish Laboratory (Chairman).

Dr. A. Franks, National Physical Laboratory (Secretary).

Dr. J. S. Halliday, Associated Electrical Industries Research Laboratory, Aldermaston.

Dr. P. B. Hirsch, Cavendish Laboratory.

Dr. J. W. Menter, Tube Investments Research Laboratory, Hinxton.

grains. These studies would be more realistic in thick specimens.

(7) Interest has grown rapidly in the properties of deposited films used in solid-state devices such as computer elements, and in micro-miniaturized electronics. These films are often about a micron thick and it should thus become possible to examine them directly, and also the film-substrate region which is of great technical importance.

Valuable application for high resolution would be the examination of high-strength alloys used in engineering. All such alloys depend for their strength on the presence of very fine precipitates. Because of inadequate resolving power it is at present impossible to study the very early stages in the formation of important phases such as the carbides and nitrides in steel. If the full theoretical resolving power were available it would also be possible to view directly distortions in the crystal lattice arising, for instance, from point defects due to damage from radiation in atomic piles.

Non-metallic Specimens. In addition to the fact that thicker specimens, which are more readily prepared, can be examined at the higher voltages, the principal advantage with non-metallic specimens lies in the reduction of radiation damage. To illustrate the point, at 100 kV the crystallinity of polymers is destroyed so rapidly that it is not possible to conduct experiments successfully for more than one or two minutes.

With regard to the study of biological material, a feature of particular value is the possibility of examining matter in a wet or living state: owing to increased penetrating power of the beam, the specimen can be enclosed in a thin-walled capsule as in the experiments of Dupouy.

Engineering Problems

It will be useful to conclude this article by enumerating some of the engineering problems associated with high resolution high-voltage microscopy.

(1) Perhaps the most formidable problem to solve in order to approach the theoretical resolving power of just over 1 Å at 1 MV is the requirement that the high-tension generator must be stable to about 5 parts in a million. This could be done, for example, with a high-voltage generator of the electrostatic or Cockroft-Walton type, stabilized by an electron velocity analyzer of the type described by Haine and Jervis.[7] In this device, some electrons, accelerated by the voltage which is to be controlled, are deflected by traversing a very stable magnetic field. Changes in the accelerating voltage will alter the path of this electron beam and thus alter the current signal collected by a suitably positioned electrode. After amplification, stabilization would be effected by feeding back this signal to the generator, possibly by means of an auxiliary proton beam.

(2) The mechanical stability of the instrument must be at least as good as the resolving power. Great care must therefore be taken to minimize the effects of vibration and thermal fluctuations.

(3) The 1 MV electron beam will generate very penetrating X-rays and precautions must be taken against radiation hazards. It will be necessary, for instance, to view the final image by an indirect method and to manipulate the specimen by the use of a remote control mechanism.

Fortunately, photographic emulsion is relatively insensitive to the very hard X-rays, and experimental results from existing high-voltage microscopes indicate that the quality of the photographs is comparable with that obtained at lower voltages.

(4) The requirements for mechanical accuracy are very stringent and machining tolerances at least as small as 40 micro-inches will have to be met.

Acknowledgements

The proposal to appoint a committee to study the possibilities of high voltage electron microscopy was made by Dr. N. P. Allen, F.R.S., of the National Physical Laboratory and his advice and encouragement for the project are gratefully acknowledged.

This paper is published by permission of the Director of the National Physical Laboratory, Sir Gordon Sutherland, F.R.S., and by permission of the Director of the A.E.I. Research Laboratory, Aldermaston, Dr. T. E. Allibone, C.B.E., F.R.S.

References

[1] Tadano, B., Katagiri, S., and Ichige, K., *J. Electron Microscopy*, p. 7, vol. 7, 1959.
[2] Popov, N. M., *Izvest. Akad. Nauk. SSSR*, p. 436, vol. 23, 1959.
[3] Kobayashi, K., Suito, E., and Shimadzu, S., *Proc. 4th International Conference on Electron Microscopy*, p. 165 (Berlin), 1958. (Berlin: Springer-Verlag, 1960.)
[4] Hashimoto, H., private communication, 1961.
[5] Dupouy, G., Perrier, F., and Fabre, R., *Comptes Rendus*, p. 627, vol. 252 (Paris) 1961.
[6] Dupouy, G., Perrier, F., and Durrieu, L., *Comptes Rendus*, p. 2836, vol. 251 (Paris) 1960.
[7] Haine, M. E., and Jervis, M. W., *Proc. IEE, Section B*, p. 265, vol. 102 (London, 1955).

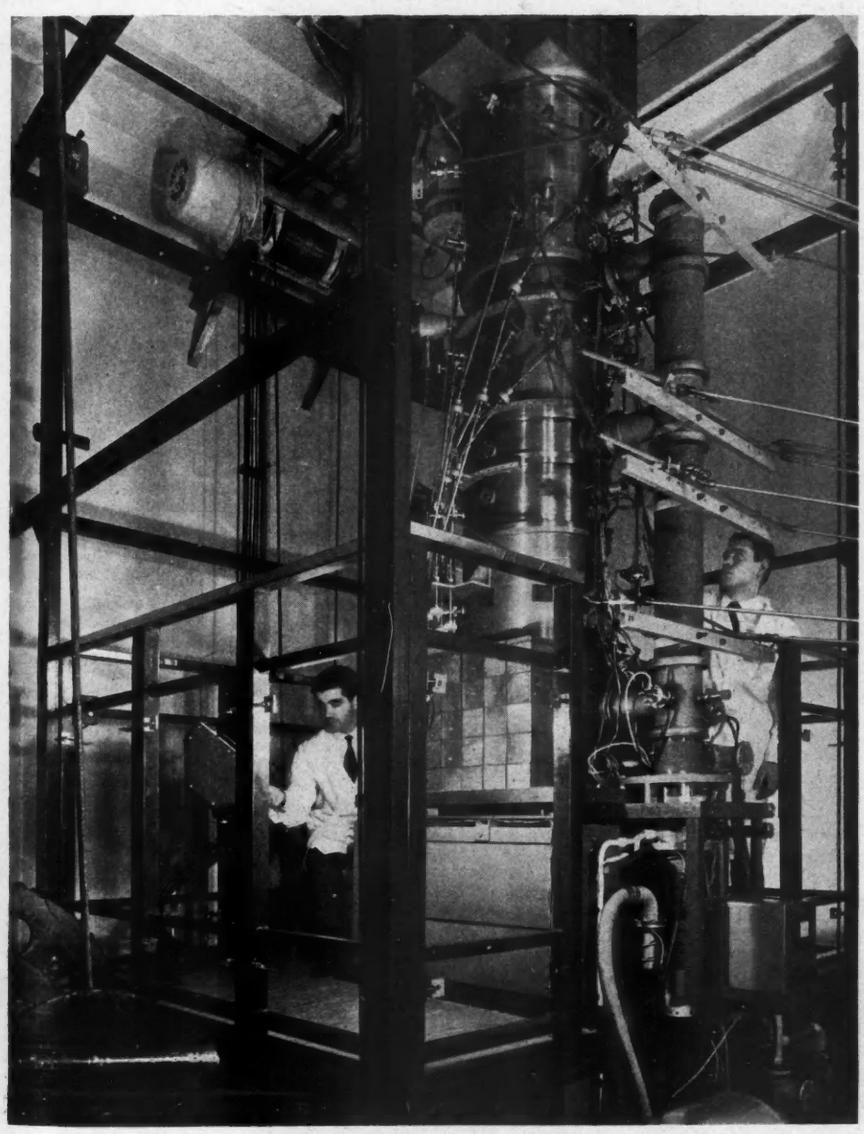
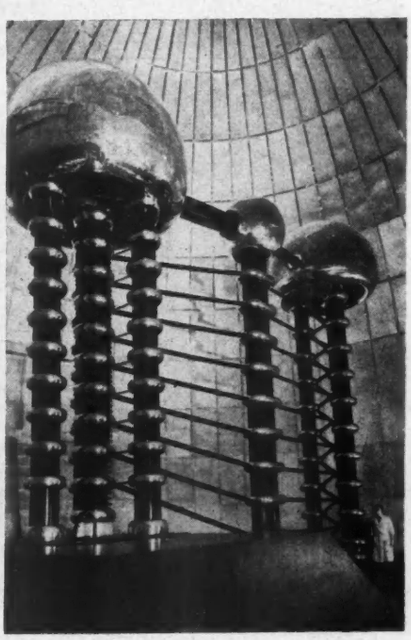


Fig. 2 (left) Column of a high-voltage electron microscope built in France under the direction of Professor G. Dupouy (photograph by J. Dieuzaide).

Fig. 3 (below) High-voltage generator of Professor Dupouy's microscope.



Gutters and Pipes—Non-Metallic

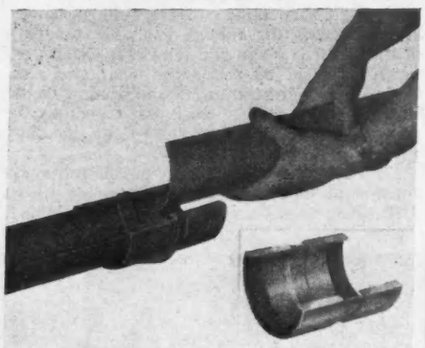
AFTER a long and successful existence, the cast iron gutter and fall pipes have come up against strong competition. There are two main opponents now, aluminium and, more recently, plastics. They have similar advantages of resistance to corrosion and lightness, and the plastics have the additional point of being very easy to cut and fit.

Plastics rain water goods are self-coloured and do not require painting during their lifetime. They are more durable than metals as regards corrosion and, while not fireproof, are fire resistant and in general will not support combustion. Their lightness—only $\frac{1}{4}$ lb per ft run for standard 4 in gutter—makes them very easy to handle and they are strong enough to rest a ladder against them without damage, as the left-hand illustration shows. They are however more sensitive to changes in temperature than is cast iron, the thermal expansion being of the order of $\frac{1}{16}$ in in a 10 ft length for a change of 10° F. All the systems described have allowed for this in the jointing arrangements—which is a simple matter as there is no cementing and all joints are made by sliding. The tendency to soften in very hot weather can be met quite adequately by providing a proper number of brackets. In any case, in most houses, the unsupported stretches are never great and it is rare that the upper working temperature limit (140° F for unplasticized pvc) is encountered in this country. Care is required during storage, however, to avoid deformation and though normally the goods can be handled without much care, in intensely cold weather there is a tendency for them to become brittle.

One of the first in the field was the pitch fibre pipe made by the Key Engineering Company Limited, Larkfield, near Maidstone, Kent. Their product is particularly suited to fall and soil pipes and has the benefits of lightness and rigidity. The Key single stack system successfully passed the tests of the Building Research Station.

The Terrain system introduced by Burn Brothers (London) Limited, Cray Avenue, St. Mary Cray, Orpington, Kent, and designed by A.B. Plastics Limited, utilizes unplasticised and unmodified pvc supplied by ICI. The complete range includes both soil and waste piping as well as rainwater goods. Trunking for ventilation systems is also made. The method of joining lengths of gutter is shown in the lower drawing. The main length of gutter is designed to slide into slots in the jointing brackets, neither cement nor mastic being required. The brackets are fixed to the fascia board of the house by a single nickel plated screw. Intermediate support brackets are available which slide on to the gutter length. End blanks or stops are fixed to the gutter with a solvent weld cement which softens the base material, so forming a true weld. There are ten unit fittings in the system including angles, outlets, pipe sockets, branches, and bends. The normal self-colour is black.

Pvc is also used for the Rymway system shown in the upper right illustration. Gutters, drain pipes and fittings are made light grey in colour and have a glossy finish. As the illustration shows, the lengths of gutter snap into position under the lugs of the fittings and the die cast aluminium brackets, which are fixed to the fascia board by two screws. The joints are sealed by means of a built-in jointing strip already positioned in the sockets of the fittings. Cushions on the brackets provide the whole assembly with a firm flexible grip. No jointing compound is required for the down pipes, which have push-pull fittings. The Rymway system has been developed by a consortium of Redland Tiles Limited, Castle Gate, Reigate, Surrey, Yorkshire Imperial Metals Limited, and P. H. Muntz and Barwell Limited.

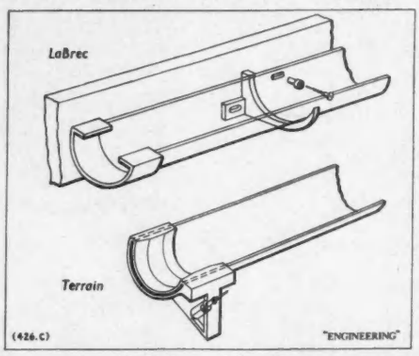


(*Above*) *With the Rymway system the gutter just snaps into the jointing piece. Die cast aluminium brackets are used.*

(*Left*) *Plastics guttering is strong enough to support a ladder without damage.* (*LaBrecque*)

(*Below*) (*Upper*) *A sliding fit is used in the La-Brecque polyethylene system which has plastics brackets welded to the gutter.*

(*Lower*) *The gutter slides into the slot of the bracket in the Terrain system which employs pvc.*



The material used by the LaBrecque Engineering Company Limited, is high density polyethylene, self-coloured black. No metal is used other than for the fixing screws. The supporting brackets, also high density polyethylene, are welded to the gutter at approximately 2 ft 5 in intervals and every other bracket is supplied with a bottom lug. Even the pipe clips and fixings are plastics, though with metal clamping screws. Stop ends for the gutter can be supplied for internal or external fitting and with or without a fixing bracket. The gutter is fixed directly to fascia board by galvanized screws and distance pieces. The fittings are supplied with bracket attached and are complete with synthetic rubber sealing strips.

ENGINEERING

Published every Friday by Engineering Ltd. at 36 Bedford Street, London WC2, England.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

Chairman
J. A. Dixon, M.A., A.M.I.Mech.E.

Editor
F. B. Roberts, M.B.E., M.I.Mech.E.

Deputy Editors
D. Fisher, Ph.D., B.Sc., A.M.I.C.E., A.M.I.Mech.E.,
A. A. H. Scott, B.Sc., A.M.I.Mech.E.

Department Editors

Atomic Review
D. d'A. R. Blackwall, B.Sc.

Book Reviews
A. A. H. Scott (Deputy Editor)

Construction
D. Fisher (Deputy Editor)

Design
J. T. Godfrey

Events in Advance
J. E. Dodsworth

Impact, Human Element, Companies, Marketing
J. D. F. Perry

Metals and Materials
D. C. E. Gribble, B.Sc.

New Plant and Equipment
P. B. Jones

At Home
A. A. H. Scott (Deputy Editor)

Product Profile
K. M. Brown

Production
G. T. Page, M.A.

Research and Development
R. A. Coffee, D.I.C., A.M.Brit.I.R.E.

SUBSCRIPTION MANAGER
G. A. Roberts

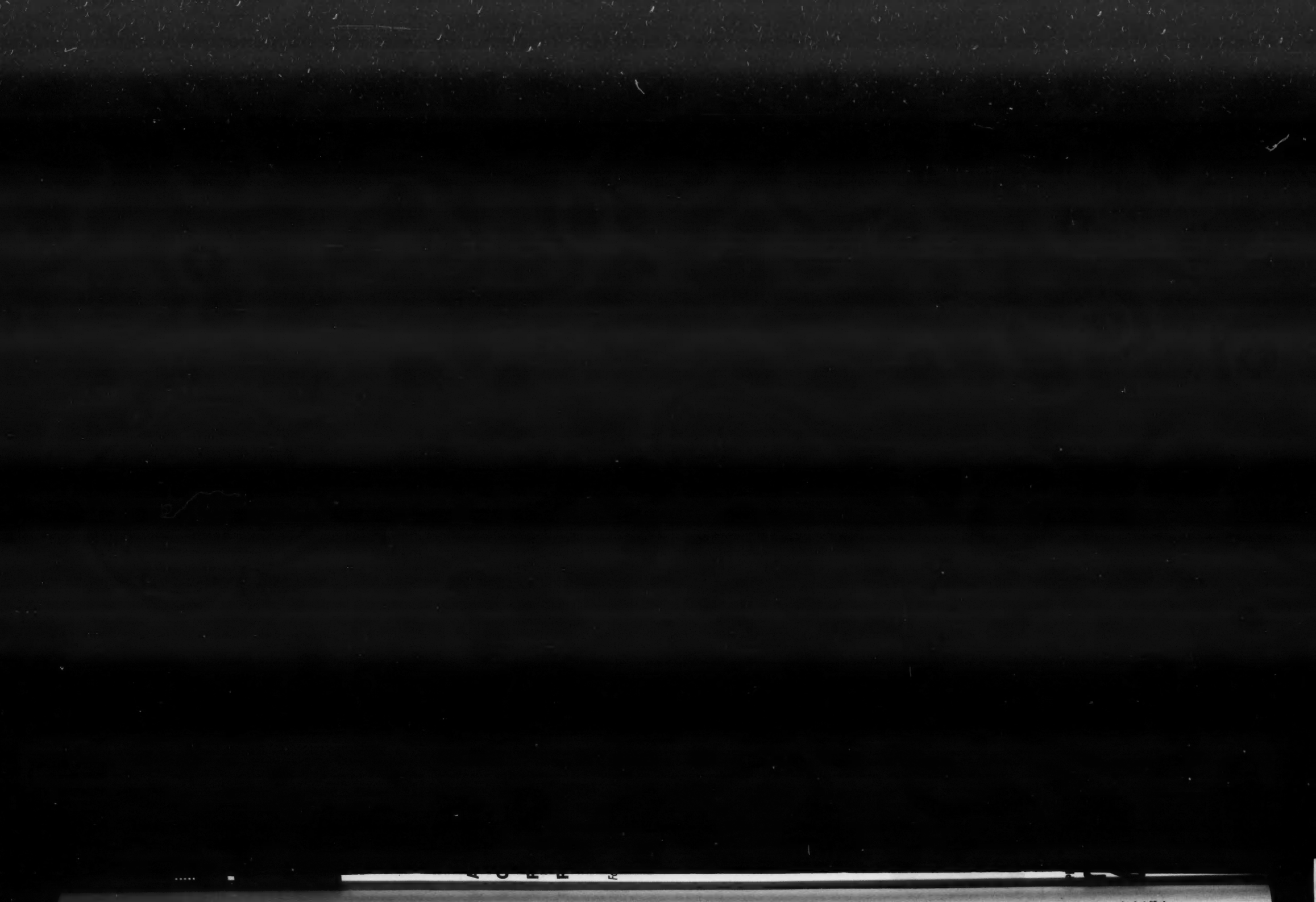
ADVERTISEMENT MANAGER
G. H. Dixon, M.A.

Contributed Articles
Notes for the guidance of contributors are available from the Editor. Contributed articles usually carry the author's name when published; they should be exclusive to ENGINEERING. When an article is accepted for publication the author is normally advised of the planned publication date.

Subscription Rates
One year, inland and abroad £5 10*s* (Canada, £5 5*s*). Three months 27*s* 6*d* all countries. Single copies 2*s* 7*d* post paid.

Back Numbers
Back numbers, from recent issues to certain of the earliest issues from 1866, are available at the usual price for single copies.

Reprints
Reprints of articles which have been published in ENGINEERING can be supplied. Requests for quotations, stating the quantity required, should be addressed to the Reprints Department.

Engineering Information Service
Assistance is available from Engineering Information Service in obtaining information, and in locating sources of information, both technical and commercial. EIS deals, for example, with names of makers and suppliers of plant and equipment, technical data on design, markets for engineering products, and the compilation of references to information on specific topics. Inquiries should be addressed to Engineering Information Service, 36 Bedford Street, London, WC2.

Advertisement Rates
The rates for advertising in the classified advertisement sections (Appointments, Company Meetings), Trade and Technical) are given in those sections. The Rate Card, covering all advertisements including display, is available from the Advertisement Manager.